



Smithsonian Institution

Office of Planning, Design & Construction

SPECIFICATIONS

PROJECT NO.: 2533105

PROJECT TITLE: **Construct Arabian Leopard Habitat (ALF)
Phase 2 - Habitat & Animal Care Building**

FACILITY: **National Zoological Conservation Biology Institute (NZCBI)**

PACKAGE: **65% Construction Documents - FOR REFERENCE ONLY**

DATE: June 15, 2026

This project is approved as being in conformance with applicable provisions of the Smithsonian Directive (SD) 410.

Michael J. Carrancho, P.E., Deputy Director

Date

TABLE OF CONTENTS

COVER SHEET

TABLE OF CONTENTS

NOTE: SECTIONS NOTED WITH ** ARE WRITTEN AND PROVIDED BY SMITHGROUP CONSULTANTS

DIVISION 00 - PROCUREMENT AND CONTRACTING REQUIREMENTS

SECTION 00 0107 - SEALS PAGE

DIVISION 01 - GENERAL REQUIREMENTS

SECTION 01 1000 – SUMMARY (SI)

SECTION 01 2300 – ALTERNATES / OPTIONS (SI)

SECTION 01 2500 – SUBSTITUTION PROCEDURES (SI)

SECTION 01 2600 – CONTRACT MODIFICATION PROCEDURES (SI)

SECTION 01 2900 – PAYMENT PROCEDURES (SI)

SECTION 01 3100 – PROJECT MANAGEMENT AND COORDINATION (SI)

SECTION 01 3200 – CONSTRUCTION PROGRESS DOCUMENTATION (SI)

SECTION 01 3233 – PHOTOGRAPHIC DOCUMENTATION (SI)

SECTION 01 3250 – BIM REQUIREMENTS (SI)

SECTION 01 3300 – SUBMITTAL PROCEDURES (SI)

SECTION 01 3573 - DELEGATED DESIGN REQUIREMENTS AND PROCEDURES

SECTION 01 4000 – QUALITY REQUIREMENTS (SI)

SECTION 01 4200 – REFERENCES (SI)

SECTION 01 5000 – TEMPORARY FACILITIES AND CONTROLS (SI)

SECTION 01 5639 – TEMPORARY TREE AND PLANT PROTECTION (SI)

SECTION 01 5715 – TEMPORARY NOISE AND VIBRATION CONTROLS (SI)

SECTION 01 6000 – PRODUCT REQUIREMENTS (SI)

SECTION 01 7300 – EXECUTION REQUIREMENTS (SI)

SECTION 01 7419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL (SI)

SECTION 01 7700 – CLOSEOUT PROCEDURES (SI)

SECTION 01 7823 – OPERATION AND MAINTENANCE DATA (SI)

SECTION 01 7839 – PROJECT RECORD DOCUMENTS (SI)

SECTION 01 7900 – DEMONSTRATION AND TRAINING (SI)

SECTION 01 8113.15 – SUSTAINABLE DESIGN REQUIREMENTS – LEED V4 BD+C

SECTION 01 9113 - GENERAL COMMISSIONING REQUIREMENTS

DIVISION 02 - EXISTING CONDITIONS

SECTION 02 4116 - STRUCTURE DEMOLITION

SECTION 02 4119 – SELECTIVE DEMOLITION **

DIVISION 03 - CONCRETE

SECTION 03 3000 - CAST-IN-PLACE CONCRETE **
SECTION 03 3500 – CONCRETE COLOR AND FINISHING **
SECTION 03 3713 – SHOTCRETE **

DIVISION 04 - MASONRY

SECTION 04 2200 – CONCRETE UNIT MASONRY
SECTION 04 4313.13 – ANCHORED STONE MASONRY VENEER

DIVISION 05 - METALS

SECTION 05 5000 – METAL FABRICATIONS
SECTION 05 5213 - PIPE AND TUBE RAILINGS
SECTION 05 7800 – DECORATIVE METAL BATTENS

DIVISION 06 - WOOD, PLASTICS, AND COMPOSITES

SECTION 06 1000 - ROUGH CARPENTRY
SECTION 06 1600 – SHEATHING
SECTION 06 4116 - PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

DIVISION 07 - THERMAL AND MOISTURE PROTECTION

SECTION 07 1326 - SELF-ADHERING SHEET WATERPROOFING
SECTION 07 1416 – COLD FLUID-APPLIED WATERPROOFING
SECTION 07 2100 - THERMAL INSULATION
SECTION 07 2600 - VAPOR RETARDERS
SECTION 07 2726 - FLUID-APPLIED MEMBRANE AIR BARRIERS
SECTION 07 3116 - METAL SHINGLES
SECTION 07 6200 - SHEET METAL FLASHING AND TRIM
SECTION 07 7253 – SNOW GUARDS
SECTION 07 9200 - JOINT SEALANTS
SECTION 07 9219 – ACOUSTICAL JOINT SEALANTS
SECTION 07 9513.16 - EXTERIOR EXPANSION JOINT COVER ASSEMBLIES

DIVISION 08 - OPENINGS

SECTION 08 1613 - FIBERGLASS (FRP) DOORS AND FRAMES
SECTION 08 3453 – ANIMAL ENCLOSURE CAGING AND DOORS **
SECTION 08 4313 - ALUMINUM-FRAMED STOREFRONTS
SECTION 08 4400 – GLAZED CURTAIN WALL
SECTION 08 7100 - DOOR HARDWARE **
SECTION 08 8000 – GLAZING
SECTION 08 8813 – GLASS VIEWING PANELS **
SECTION 08 8853 – SECURITY GLAZING
SECTION 08 9119 – FIXED LOUVERS

DIVISION 09 - FINISHES

SECTION 09 0561.13 - MOISTURE VAPOR EMISSION CONTROL
SECTION 09 2116.23 – GYPSUM BOARD SHAFT WALL ASSEMBLIES
SECTION 09 2216 - NON-STRUCTURAL METAL FRAMING
SECTION 09 2900 - GYPSUM BOARD
SECTION 09 3013 - CERAMIC TILING
SECTION 09 5113 - ACOUSTICAL PANEL CEILINGS
SECTION 09 6723 - RESINOUS FLOORING
SECTION 09 9123 – INTERIOR PAINTING
SECTION 09 9600 - HIGH-PERFORMANCE COATINGS

DIVISION 10 - SPECIALTIES

SECTION 10 2800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

DIVISION 11 - EQUIPMENT

SECTION 11 1313 - LOADING DOCK BUMPERS
SECTION 11 3013 - RESIDENTIAL APPLIANCES
SECTION 11 4000 - FOODSERVICE EQUIPMENT
SECTION 11 9519 – ANIMAL EQUIPMENT **

DIVISION 12 - FURNISHINGS

SECTION 12 1423 – SIMULATED NATURE – ARTIFICIAL TREES AND PLANTS **
SECTION 12 3553.13 – METAL LABORATORY CASEWORK
SECTION 12 3661.16 – SOLID SURFACING COUNTERTOPS

DIVISION 13 – SPECIAL CONSTRUCTION

SECTION 13 3100 – SPECIAL STRUCTURES **
SECTION 13 3120 – CABLE SUPPORTED MESH STRUCTURES **

DIVISION 21 - FIRE SUPPRESSION

SECTION 21 3000 – FIRE SPRINKLER AND STANDPIPE SYSTEMS

DIVISION 22 – PLUMBING

SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

SECTION 22 0516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

SECTION 22 0517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

SECTION 22 0518 - ESCUTCHEONS FOR PLUMBING PIPING

SECTION 22 0519 - METERS AND GAGES FOR PLUMBING PIPING

SECTION 22 0523.12 - BALL VALVES FOR PLUMBING PIPING

SECTION 22 0523.14 - CHECK VALVES FOR PLUMBING PIPING

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

SECTION 22 0716 - PLUMBING EQUIPMENT INSULATION

SECTION 22 0719 - PLUMBING PIPING INSULATION

SECTION 22 0800 - COMMISSIONING OF PLUMBING

SECTION 22 1113 - FACILITY WATER DISTRIBUTION PIPING

SECTION 22 1116 - DOMESTIC WATER PIPING

SECTION 22 1119.1 - DOMESTIC WATER PIPING SPECIALTIES

SECTION 22 1119.2 - DOMESTIC WATER PIPING SPECIALTIES **

SECTION 22 1123 - DOMESTIC WATER PUMPS

SECTION 22 1313 - FACILITY SANITARY SEWERS **

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

SECTION 22 1319.13 - SANITARY DRAINS

SECTION 22 1329 - SANITARY SEWERAGE PUMPS

SECTION 22 1413 - FACILITY STORM DRAINAGE PIPING

SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES

SECTION 22 3400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

SECTION 22 4213.13 - COMMERCIAL WATER CLOSETS

SECTION 22 4216.13 - COMMERCIAL LAVATORIES

SECTION 22 4216.16 - COMMERCIAL SINKS

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

SECTION 23 0100 - COMMON WORK RESULTS FOR HVAC
SECTION 23 0413 - COMMON SUBMITTAL REQUIREMENTS FOR HVAC
SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
SECTION 23 0516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
SECTION 23 0518 - ESCUTCHEONS FOR HVAC PIPING
SECTION 23 0519 - METERS AND GAUGES FOR HVAC PIPING
SECTION 23 0523 - GENERAL-DUTY VALVES FOR HVAC PIPING
SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
SECTION 23 0548.13 - VIBRATION CONTROLS FOR HVAC
SECTION 23 0553 - IDENTIFICATION FOR HVAC, PIPING AND EQUIPMENT
SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC
SECTION 23 0713 - DUCT INSULATION
SECTION 23 0716 - HVAC EQUIPMENT INSULATION
SECTION 23 0719 - HVAC PIPING INSULATION
SECTION 23 0800 - COMMISSIONING OF HVAC
SECTION 23 0900 - INSTRUMENTATION AND CONTROL FOR HVAC
SECTION 23 1123 - FACILITY NATURAL-GAS PIPING
SECTION 23 2113 - HYDRONIC PIPING
SECTION 23 2116 - HYDRONIC PIPING SPECIALTIES
SECTION 23 2123 - HYDRONIC PUMPS
SECTION 23 2513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS
SECTION 23 3113 - METAL DUCTS
SECTION 23 3300 - AIR DUCT ACCESSORIES
SECTION 23 3346 - FLEXIBLE DUCTS
SECTION 23 3400 - HVAC FANS
SECTION 23 3433.13 - COMMERCIAL AIR CURTAINS
SECTION 23 3600 - AIR TERMINAL UNITS
SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES
SECTION 23 5123 - GAS VENTS
SECTION 23 5216 - CONDENSING BOILERS
SECTION 23 6423.13 - AIR-COOLED, SCROLL WATER CHILLERS
SECTION 23 7313.19 - INDOOR, CUSTOM AIR-HANDLING UNITS
SECTION 23 8216.11 - HYDRONIC AIR COILS
SECTION 23 8219 - FAN COIL UNITS
SECTION 23 8233 - CONVECTORS
SECTION 23 8239.16 - PROPELLER UNIT HEATERS
SECTION 23 8316 - RADIANT-HEATING HYDRONIC PIPING
SECTION 23 8413 - HUMIDIFIERS

DIVISION 26 – ELECTRICAL

SECTION 26 0400 - COMMON WORK RESULTS FOR ELECTRICAL
SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
SECTION 26 0523 – CONTROL VOLTAGE ELECTRICAL POWER CABLES
SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
SECTION 26 0536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS
SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL
SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND
CABLING
SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS
SECTION 26 0573 - POWER SYSTEM STUDIES
SECTION 26 0800 - COMMISSIONING OF ELECTRICAL SYSTEMS
SECTION 26 0913 - ELECTRICAL POWER MONITORING AND CONTROL
SECTION 26 0923 - LIGHTING CONTROL DEVICES
SECTION 26 0936 - MODULAR DIMMING CONTROLS
SECTION 26 0943 - NETWORK LIGHTING CONTROLS
SECTION 26 2213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
SECTION 26 2416 - PANELBOARDS
SECTION 26 2726 - WIRING DEVICES
SECTION 26 2813 - FUSES
SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS
SECTION 26 2913.01 – MANUAL AND MAGNETIC MOTOR CONTROLLERS
SECTION 26 2923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS
SECTION 26 3213 - ENGINE GENERATORS
SECTION 26 3600 - TRANSFER SWITCHES
SECTION 26 3650 - GENERATOR DOCKING STATIONS
SECTION 26 4113 - LIGHTNING PROTECTION FOR STRUCTURES
SECTION 26 4313 – SURGE PROTECTION FOR L-V ELECTRICAL POWER CIRCUITS
SECTION 26 5100 - INTERIOR LIGHTING
SECTION 26 5600 - EXTERIOR LIGHTING

DIVISION 27 - COMMUNICATIONS

SECTION 27 0500 - COMMON WORK RESULTS FOR COMMUNICATIONS **
SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS **
SECTION 27 0528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS **
SECTION 27 0528.10 – PATHWAYS FOR SECURITY SYSTEMS **
SECTION 27 0553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS **
SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS **
SECTION 27 1500 - COMMUNICATIONS HORIZONTAL CABLING **
SECTION 27 1700 - TESTING OF STRUCTURED CABLING SYSTEMS **

DIVISION 28 - ELECTRONIC SAFETY AND SECURITY

SECTION 28 0500.10 - COMMON WORK RESULTS FOR ELECTRONIC SECURITY**
SECTION 08 0507.10 – POWER SOURCES FOR ELECTRONIC SECURITY **
SECTION 28 0509.10 – SURGE PROTECTION FOR ELECTRONIC SECURITY **
SECTION 28 0531.10 - COMMUNICATIONS EQUIPMENT FOR ELECTRONIC SECURITY **
SECTION 28 0800.10 - COMMISSIONING ELECTRONIC SECURITY **
SECTION 28 1000 - ACCESS CONTROL **
SECTION 28 1515 - ELECTRIFIED LOCKING DEVICES AND ACCESSORIES **
SECTION 28 2000 – VIDEO **
SECTION 28 3100 - INTRUSION DETECTION **
SECTION 28 3111 – DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

DIVISION 31 - EARTHWORK

SECTION 31 1000 – SITE CLEARING **
SECTION 31 2300 – EARTHWORK **
SECTION 31 6333 – MICROPILES **

DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 1313.1 – CONCRETE PAVING
SECTION 32 1313.2 – CONCRETE PAVING **
SECTION 32 1316 – DECORATIVE CONCRETE PAVING
SECTION 32 1373 – CONCRETE PAVING JOINT SEALANTS **
SECTION 32 1400 – UNIT PAVING
SECTION 32 1816.13 – PLAYGROUND PROTECTIVE SURFACING
SECTION 32 3100 – METAL FENCES AND GATES **
SECTION 32 3300 – SITE FURNISHINGS
SECTION 32 8400 – LANDSCAPE IRRIGATION
SECTION 32 9115 – PLANTING SOILS **
SECTION 32 9119 – LANDSCAPE GRADING **
SECTION 32 9280 – VEGETATION CONTROL
SECTION 32 9300 – EXTERIOR PLANTINGS
SECTION 32 9300 – PLANTS **

DIVISION 33 - UTILITIES

SECTION 33 1415 – SITE WATER DISTRIBUTION PIPING **
SECTION 33 4200 – STORMWATER CONVEYANCE **

END OF TABLE OF CONTENTS

DOCUMENT 000107 - SEALS PAGE

Architect SmithGroup, Inc. Washington, DC	Structural Engineer TYLin Washington, DC
Fire Protection Engineer SmithGroup, Inc. Washington, DC	Mechanical Engineer SmithGroup, Inc. Washington, DC
Electrical Engineer SmithGroup, Inc. Washington, DC	Plumbing Engineer SmithGroup, Inc. Washington, DC

Civil Engineer Sorba Engineering Dulles, VA	Landscape Architect SmithGroup, Inc. Washington, DC
Habitat Designer SHR Studios Bainbridge Island, WA	Geotechnical Engineer Haley Aldrich Annapolis, MD
IT/AV/Telecom Engineer BrightTree Studios Pittsburgh, PA	Electronic Security M2H Protection Middletown, MD

Acoustic Engineer Metropolitan Acoustics Philadelphia, PA	Irrigation Hines Inc. Washington, DC
---	--

END OF DOCUMENT

FOR REFERENCE ONLY

SECTION 01 1000 - SUMMARY

PART 1 - GENERAL

1.1 PROJECT INFORMATION

- A. Project Identification: Construct Arabian Leopard Facility (ALF)
SF Project No. 2533105
NZP-DC: Smithsonian's National Zoo and Conservation Biology Institute (NZCBI)
3001 Connecticut Avenue, NW
Washington, D.C. 20008
- B. Smithsonian Institution Contacts:
Contracting Officer (CO) address for Fed Ex and UPS delivery: Smithsonian Institution
Attn: Virginia Chan
Office of Contracting
600 Maryland Avenue, SW, Suite 500E
Washington, DC 20024
- Contracting Officer (CO), address for USPS delivery: Smithsonian Institution
Office of Contracting
MRC 1200
P.O. Box 37012
Washington, DC 20013-7012
- Contracting Officer's Technical Representative (COTR), address for Fed Ex, USPS, and UPS delivery:
Smithsonian Institution
Attn: Ryan Swanier
Office of Planning, Design & Construction
General Services Building
National Zoological Park
3001 Connecticut Avenue, NW
Washington, DC 2000
- All references on drawings and in specifications to 'Owner,' 'SI,' 'National Zoological Park,' 'National Zoo,' 'Zoo,' or 'NZP' refer to COTR.

1.2 SUMMARY OF WORK

- A. The Work of Project is defined by the Contract Documents and consists of the following:
- I. The Contractor shall furnish all supervision, labor, materials, and equipment needed to complete Phase 2 of the Construct Arabian Leopard Facility Project located at Smithsonian Institution's National Zoological Park at 3001 Connecticut Avenue NW as set forth on the Drawings for OPDC Project No. 2533105 and in these specifications, anticipated final issue date in early October 2026 and as noted below.
- The Work includes: The Phase 2 (Habitats and Animal Care Building) for the Arabian Leopard Facility (ALF) that will be located southeast of the Connecticut Avenue entrance to the National Zoo. It will replace the former Bison Habitat and the existing Zoo in Your Backyard, which is situated along the historic Olmsted Walk, across from the Africa Trail Exhibit (currently under renovation), just north of the Elephant House, and abuts the east exit of the Panda Habitat.

2. Critical Elements of the Work: The successful Contractor shall be fully qualified to install critical elements of the Work. Upon request of the Contracting Officer, bidders shall submit a statement of qualifications to address the following critical elements of the Work:
- a. Working within an occupied, historic campus active with public, staff and animals
 - b. Coordination of specialty trades within a small site footprint
 - c. Coordination and installation of specialty animal doors, transfer systems and manually operated remote door controls.
 - d. Coordination and installation of subsurface utility systems in a congested area
 - e. Coordination and installation of subsurface drainage and water conveying systems.
 - f. Coordination and installation of radiant flooring
 - g. Coordination and installation of animal containment fencing and mesh
 - h. Coordination and installation of shotcrete faux rock and faux trees
 - i. Mitigation of sound and vibration during demolition and construction so as not to harm animals in adjacent habitats
 - j. Coordination of construction activities with Zoo operations to align with feeding schedules, DC zoning community noise regulations, Zoo hours, known and unknown animal welfare issues, veterinary care, and public events
3. Related Documents include:
- a. Arabian Leopard Facility (ALF) - Preliminary Acoustic Narrative (FOR REF ONLY), dated 1/22/26
 - b. Arabian Leopard Facility (ALF) – Geotechnical Engineering Study (FOR REF ONLY), dated 3/13/26
 - c. Arabian Leopard Facility (ALF) Phase 1 – Early Site Dwgs w-Addendum 1 (FOR REF ONLY), dated 5/11/26
 - d. Arabian Leopard Facility (ALF) Phase 1 – Early Site Dwgs w-Addendum 1 Clarifications (FOR REF ONLY), dated 5/12/26
 - e. Arabian Leopard Facility (ALF) Phase 1 – Early Site Specs w-Addendum 1 (FOR REF ONLY), dated 5/11/26
 - f. Arabian Leopard Facility (ALF) Phase 1 – Early Site Bid RFI Responses (FOR REF ONLY), dated 6/11/26
 - g. Arabian Leopard Facility (ALF) Phase 2 – Habitats & Animal Care Building 65% Design Development Drawings (FOR REF ONLY), dated 6/15/26
 - h. Arabian Leopard Facility (ALF) Phase 2 – Habitats & Animal Care Building 65% Design Development Specifications (FOR REF ONLY), dated 6/15/26
4. As-built documentation, previous project design drawings, geotechnical/soils reports, structural analysis, surveys, and other materials may be provided for supplemental reference only. Accuracy of any information provided is not guaranteed. Any information contained therein may affect the project and must be field verified.
- B. Type of Contract:
- 1. Project will be constructed under a single prime contract.
- C. Contract Time for Completion:
- 1. Work under this contract shall begin by the Contractor within ten (10) calendar days after the Notice to Proceed, unless stated otherwise in the Notice to Proceed issued by the Contracting Officer and shall be completed within the total contract time of **578** calendar days. All work, including project close-out activities, shall be completed in every respect within the contract time.

2. The start date and completion date shall be as stated in the Notice to Proceed issued by the Contracting Officer.

1.3 BIDDER EXAMINATION OF SITE

- A. Every effort has been made to indicate all work necessary to complete the project as identified. All bidders shall carefully examine the premises during the bid period and satisfy themselves as to the extent, nature, and location of the work, general and local conditions, particularly those bearing on transportation, disposal, handling and storage of materials, access routes, availability of labor, water, electric, uncertainties of the weather, type of equipment and facilities needed for the successful execution of the work.
- B. Pre-Bid Conference and Site Visit. Before or during the bidding period, a scheduled pre-bid conference and site visit will be announced by the COTR. The purpose of the scheduled meeting is to provide an opportunity for all bidders to review the project site. Any comments, information or discussion during the site visit shall not modify the contract documents.
- C. This project requires special arrangements for access to a non-public area. Access to the site may be restricted at times other than during the scheduled visit.

1.4 ACCESS TO SITE

General: Contractor shall have limited use of project site for construction operations as indicated on Drawings by the Contract limits and as indicated by requirements of this Section.

- A. Use of Site: Limit use of Project site to areas within the Contract limits indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.
 1. Limits: Confine construction operations as indicated on the contract drawings.
 2. Driveways, Walkways and Entrances: Keep driveway, parking areas, and entrances serving premises clear and available to the Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.
 - a. Schedule deliveries to minimize use of driveways and entrances by construction operations.
 - b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

1.5 COORDINATION WITH OCCUPANTS

- A. Owner Limited Occupancy of Completed Areas of Construction: Owner reserves the right to occupy and to place and install equipment in completed portions of the Work, prior to Completion of the Work, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and limited occupancy shall not constitute acceptance of the total Work.
 1. Obtain a Certificate of Occupancy from authorities having jurisdiction before any partial Owner occupancy.

1.6 WORK RESTRICTIONS

- A. Work Restrictions, General: Comply with restrictions on construction operations.

1. Comply with limitations on public use and with other requirements of authorities having jurisdiction.
- B. Work Restrictions, Adjacent Panda Habitats
1. Anticipated Stop Work Events – Due to the proximity of active panda habitats and associated care facilities to the Arabian Leopards project area, the Contractor shall anticipate any Stop Work Notices issued by the Contracting Officer's Technical Representative (COTR) as required by animal care staff to protect animal welfare. Stop Work Notices shall be considered a normal and expected part of project execution and shall not constitute grounds for additional cost or time.
 2. Potential Panda Relocations – Depending on the nature, duration, and intensity of adjacent construction activities, pandas may require temporary relocation to alternate enclosure spaces. Such relocations require advance notice, schedule coordination, and enhanced communication between the Contractor and the animal care team. The Contractor shall plan work sequencing to support these relocations and shall incorporate required coordination into the project schedule.
 3. Means and Methods Affecting Panda Behavior – The Contractor shall submit detailed means and methods for any construction activities that may influence panda behavior, including but not limited to noise, vibration, visual disturbance, equipment movement, or changes in access patterns.
 4. Daily Coordination Requirements for Sensitive Work – In addition to standard two week look ahead schedules, the Contractor shall conduct a daily coordination meeting with designated animal care team members prior to the start of sensitive work. This requirement applies especially to but not limited to high decibel, high impact, or otherwise disruptive activities. The purpose of the meeting is to confirm planned work; review required mitigations and resolve any animal care concerns before work begins.
- C. On-Site Work Hours: Limit work in the project area to normal business working hours of 6 a.m. to 3:30 p.m., Monday through Friday, unless otherwise indicated.
1. Weekend Hours: Contractor shall seek approval from COTR.
 2. Early Morning Hours: Contractor shall seek approval from COTR
 3. Hours for Utility Shutdowns: Shall occur during "OFF HOURS" as determined by the COTR.
- D. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and only after providing temporary utility services according to requirements indicated:
1. Shall occur during "OFF HOURS" as determined by the COTR.
 2. Existing emergency generators are not available for contractor's required power shutdowns.
- E. Noise, Vibration, and Odors: Coordinate operations that may result in high levels of noise and vibration, odors, or other disruption to Owner occupancy with Owner.
1. Notify **Owner** not less than **three** days in advance of proposed disruptive operations.
- F. Smoking is only allowed in COTR approved designated contractor locations. Contractor shall keep the area clean.
- G. Traffic Control. The GC is to provide a flagger with SI issued badge for controlling access and managing all traffic entering NZP property SI\NZP staff will need access to occupied areas adjacent to but outside of the project construction zone, such as the Kudu yard See drawing C140 for additional requirements. Contractor will provide at least one traffic control

professional at each unlocked project vehicle/staff entrance during construction operating hours. During off hours the entire work area shall be fenced off and locked.

1. **TRAFFIC PERSONNEL.** The Contractor shall provide all necessary personnel for traffic control. The following personnel shall be required:

(1) **TRAFFIC SAFETY OFFICER.** The Contractor shall provide a competent traffic safety officer. The traffic safety officer shall be thoroughly experienced in and qualified for maintenance of traffic safety control work. Prior to commencing work requiring traffic control management, the Contractor shall certify in writing that the proposed Traffic Control Officer, and any designated substitute, has been certified by the American Traffic Safety Services Association (ATSSA). The Contractor shall submit a certificate verifying successful completion of the ATSSA course and a summary of the Traffic Safety Officer's field experience in the operation of work zone traffic control. Training provided by DDOT, or private firm may be approved provided that the following minimum requirements are met:

- a) Successful completion of a comparable work zone traffic control course including evidence of passing a written examination on the material presented in the course.
- b) A minimum of one year of documented field experience in work traffic control. The traffic safety officer or an approved substitute, in case of forced absence, is expected to perform the duties on a regular basis and ensure that all traffic maintenance operations are running smoothly at all times by conducting regular inspections for the duration of the project, particularly during peak hours. The traffic safety officer's prime duty but not sole duty shall be the responsibility for the Contractor's maintenance of traffic operations. Duties shall include, but not be limited to, the following:
 - (a) Understand the requirements of the contract provisions.
 - (b) Be responsible for assuring compliance of the Contractor's maintenance and protection of traffic relative to the requirements of the contract provisions.
 - (c) Be responsible for assuring that all deficiencies are corrected.
 - (d) Be responsible for coordinating maintenance of traffic operations with the COTR.
 - (e) Supervise the installation and removal of all temporary traffic control devices and pavement markings.
 - (f) Be responsible for daily inspection of the work zone traffic control devices. Inspection results shall be recorded in a Traffic Control Device Inspection Log.
 - (g) Monitor traffic flows to confirm that delays in the work zone are kept to a minimal duration for Zoo traffic.

(2) **FLAGGERS.** Contractor shall provide all necessary flaggers required to properly maintain traffic through the work zone. Flaggers shall have completed flagger training and shall be certified by ATSSA or another approved agency or firm.

- a) Contractor must submit certification of individuals prior to working on the site.
- b) Flaggers shall properly use all required safety gear (vests, flags, cones, tape, flashlights, etc.)

4.2 USE OF PREMISES

C. Use of Site: During the construction period, the Contractor shall have full use of the majority of the premises for construction operations within the "Limits of Construction." The Contractor's use of the premises will be limited by the Smithsonian Institution's right to perform work as indicated below. Security of the construction site is the responsibility of the Contractor.

1. Staff operations within buildings surrounding the project site

2. Contractor Parking: One parking space will be assigned to the Contractor for use during the contract period. The space will be located as close to the project site as possible. Coordinate with COTR.
 3. The assigned space can only be used by the company vehicle. The vehicle must be clearly marked with company name and/or logo. The permit shall be displayed on the vehicle dashboard on the driver's side. Vehicles not in compliance with this clause are subject to ticketing and towing by the NZP police. Costs associated with parking violations shall be the sole responsibility of the Contractor.
 4. Parking spaces will not be provided for the Contractor's employees. Employees will be required to comply with the NZP's pay parking regulations.
 5. Personnel Vehicles may not be parked on the jobsite or roadways.
 6. The Contractor is expected to provide whatever means necessary to protect persons and property from work activities.
- D. Use of Utilities: Existing utilities are available for the Contractor's use. See Division 01 Section 01500 "Temporary Facilities and Controls."
- E. Off-Hours Work and Overtime: For each occasion, the Contractor chooses to work on Saturdays, Sundays, or Smithsonian holidays, or during hours other than 6:00AM – 3:00PM, obtain written permission from the COTR at least 5 working days in advance. The Zoo is located in neighborhood community surroundings, which greatly limits the option to work off hours.
- F. Temporary Construction Barriers: The contractor shall coordinate installation with the COTR at least 5 working days prior to the scheduled construction barrier installation.
- G. Work Stoppages and Deferrals for Animal Issues: Any issue posing a risk to zoo animal welfare may be considered equivalent to a safety hazard for humans.

4.3 CONTRACTOR BEHAVIOR

- C. Dress and Deportment: Contractors and subcontractors on SI-property shall conduct themselves in a manner appropriate to a public place and animal care facility, abiding by all federal, state, and local laws and ordinances, as well as Smithsonian Institution directives. Contractor and subcontractor personnel shall be fully and appropriately clothed at all times. The COTR may require immediate removal of any individual from the premises and Project for:
1. Unacceptable dress, demeanor, disruptive conduct or
 2. Unauthorized interaction, feeding, or harassment of any zoo animals or
 3. Unauthorized entry into animal containment or non-public area or
 4. Tampering with any animal containment barrier, device, gate, or lock.
- D. The consumption of alcoholic beverages by the Contractor's personnel is prohibited in/on all Smithsonian property, buildings, or leased space.
- E. Smoking or carrying lighted tobacco products is prohibited in all Smithsonian buildings and exhibition/public spaces, in areas where hazardous materials are stored or handled. Acceptable areas for smoking are outside of buildings as designated by the Smithsonian.
- F. The possession, sale, or use of narcotic or other illegal substances or contraband by Contractor employees is strictly prohibited in/on all Smithsonian property, facilities, and leased spaces. Working on the project under the influence of alcohol or illegal substances is strictly prohibited.

4.4 JOB-SITE SAFETY AND RELATED SUBMITTALS

- C. Safety Coordinator: The Contractor shall designate a person responsible and accountable for personnel safety at both corporate and project level at the project site for the duration of the project. Contracts specifically requiring safety or industrial hygiene personnel shall include a copy of their resumes. Qualifications for the Safety Coordinator shall include the OSHA 30-hour course or equivalent course.
- D. SUBMITTALS:
1. Job-Site Safety Plan: Submit a Job-Site Safety Plan that addresses safe construction operations by the contractor within 30 calendar days of the Contract Award and at least 10 calendar days prior to mobilization to the site for approval by the COTR. Detail the procedures, designated persons, instructions, and reports to be used to assure job-site safety for all contractors, subcontractors, Smithsonian personnel, the public, and others on the site. Safety plan shall include adherence to all applicable provisions of Smithsonian Directive 419 (SD419) and all safety standards issued by the Safety Officer of the National Zoological Park.
 5. Site Specific Safety Plan: Upon award of this contract, the contractor shall provide a Site-Specific Safety Plan (SSSP). The SSSP is a safety and health policy and program document and outlines how the contractor will safely conduct their work. This plan shall be job-specific and shall also address any unusual or unique aspects of the project or activity for which it is written. The SSSP shall interface with the employer's overall safety and health program, and a copy shall be available on the work site. Any portions of the employer's overall safety and health program that is referenced in the SSSP shall be included as appropriate. The plan shall include but not limited to the following:
 - a. Signature Sheet that must include plan concurrence (e.g., Chief of Operations, Corporate Chief of Safety, Corporate Industrial Hygienist, project manager or superintendent, project safety professional, project QC). Provide concurrence of other applicable corporate and project personnel (Contractor).
 - b. Background Information that must include Brief project description, description of work to be performed, and location; phases of work anticipated these will require a Job Hazard Analysis (JHA's). OSHA 3071
 - c. Statement of Safety and Health Policy
 - d. Responsibilities and lines of Authority
 - e. Subcontractors and Suppliers
 - f. Training
 - g. Safety and Health inspections that include assignment of responsibilities for a minimum daily/weekly job site safety and health inspection during periods of work activity level of technical proficiency needed to perform the inspections, proof of inspector's training/ qualifications.
 - h. Accident Reporting
 - i. Plans (programs, procedures) required by the Safety Manual. Based on a risk assessment of contracted activities and on mandatory OSHA compliance programs, the Contractor shall address all applicable occupational risks and compliance plans. Using the 29 CFR 1926 and/or current and accepted procedures in the EM 385-1-1 as a guide.
 - j. Risk Management Processes Detailed project-specific hazards and controls shall be provided by a Job Hazard Analysis (JHA) for each major phase/activity of work, including but not limited to work involving confined space, fall protection, trenching/excavation, crane/rigging, steel erection, hot work, protection of the

- public, scaffolding, and other activities that involve high risk potential.
- k. Jobsite supervisor/superintendent shall sign safety plan and JHA submissions with a final approved copies kept on the jobsite for operational references.
 - l. Project Evaluation for OSHA's silica standard (29 CFR 1926.1153) focuses on reducing exposure to respirable crystalline silica 12.
Key requirements include:
 - i. Lowering the permissible exposure limit (PEL) from 250 ug/m3 TWA to 50 ug/m3 TWA.
 - ii. Implementing engineering controls, respiratory protection, a written plan, proper training, ongoing medical surveillance, and oversight by a competent person.
- C. Occupational Safety and Health: This contract is subject to Title 29 of the Code of Federal Regulations, Part 1910 "Occupational Safety and Health Standards" and Part 1926 "Safety and Health Regulations for Construction" pursuant to the Occupational Safety and Health Act (OSHA) of 1970 administered by the US Department of Labor, Occupational Safety and Health Administration.
- D. Emergency Assistance: Post at the site telephone numbers for reporting emergencies, including the Smithsonian Office of Protection Services (OPS), ambulance, police, fire department, gas utility, electric utility, water/sewer utility, poison prevention aid, and hazardous- waste handling. Post this information in a conspicuous location within the project area prior to the start of any work at the site.
- E. Safety Signs: Post legible accident prevention signs in construction areas in accordance with OSHA standards. Safety signs shall conform to ANSI 235.1, and 235.2 Vehicular traffic control devices, barricades, and signals shall conform to ANSI D6.1.
- F. Report of Accident or Illness: In the event of any accident or illness for which medical assistance is required, any criminal actions, or any fire, notify the appropriate authority (ambulance, police, and fire department), Smithsonian Security, and the COTR.
- G. Emergency Evacuation: Post evacuation routes and facility emergency/self-protection plans at the site and train all employees in emergency procedures. In the event of a fire, immediately activate the alarm at the nearest fire alarm pull station and notify Zoo Police at (202) 633-4111. Upon the activation of the audible alarm, the building will be evacuated. No personnel shall reenter the facility until security personnel signal that the building is safe.
- H. Contractor Personnel to be contacted: Submit a written list of 24-hour emergency telephone numbers and names of persons to contact for the General Contractor superintendent and for each major sub-contractor working on the project site. The initial list shall be submitted to the COTR at the Preconstruction Meeting. Update and resubmit this list to the COTR as changes occur.

1.10 TOXIC AND HAZARDOUS SUBSTANCES

- A. Submit to the COTR, at least thirty (30) working days prior to their intended use, a written list of toxic and hazardous substances that will be used on the project and an NZP Material Approval Form for each. Submit a "Material Safety Data Sheet" similar to OSHA Form No. 20 for these substances to identify the following information:
1. Product Identification
 2. Hazardous Ingredients
 3. Physical Data
 4. Fire and Explosion Hazard Data
 5. Health Hazard Data
 6. Emergency and First Aid Procedures

7. Reactivity Data
8. Spill or Leak Procedures
9. Special Protection Information
10. Special Precautions

- B. Monitor the use of all toxic and hazardous substances to ensure that the specified Threshold Limit Values (TLV's) and/or Permissible Exposure Limits (PEL's) are not exceeded. Exposure of the Contractor's personnel and Smithsonian Institution employees and visitors to air-borne or any other physical contact with any substance shall not exceed allowable concentrations specified in:

1. "Threshold Limit Values and Biological Exposure Indices" of the American Conference of Governmental Industrial Hygienists, and
2. Title 29 CFR Part 1910, Subpart Z - "Toxic and Hazardous Substances" of the Occupational Safety and Health Standards.

- C. Provide methods, means, and facilities to prevent contamination of soil, water, and atmosphere from discharge of noxious, toxic substances and pollutants produced by construction operations. Remove contaminated waste in compliance with applicable laws and regulations.
- D. All containers used for hazardous chemicals shall be properly labeled. Labels should list at least the chemical identity, appropriate hazard warnings, and the name and address of the manufacturer, importer, or other responsible party.
- E. To achieve compliance with the requirements of this section, administration or engineering controls shall first be implemented whenever feasible. When such controls are not feasible to achieve full compliance, protective equipment or other protective measures shall be used to keep exposure of all persons within the prescribed limits. Descriptions of equipment or technical measures to be used for this purpose must be submitted to the COTR for approval. The Contractor's requirements for compliance with all applicable local, federal, and state regulations remain in force.

1.11 PERSONAL PROTECTIVE EQUIPMENT

- A. Personal protective equipment for eyes, face, ears, nose, head, extremities, and/or full body shall be provided, used, and maintained by the Contractor whenever necessitated by reasons of hazards encountered in a manner capable of causing illness, injury, or impairment in the function of any part of the body.
- B. Persons required to use personal protective equipment shall be thoroughly trained. Training programs shall, as a minimum, meet OSHA and EPA requirements where applicable. The Contractor shall submit proof and criteria for employee training as requested.

1.12 GENERAL SECURITY REQUIREMENTS

- A. Prior to the start of work on the site, submit to the COTR, a list of the names, and phone numbers of all Contractor and subcontractor employees. Identify the Prime Contractor and each subcontractor and trade. Update list as necessary to accurately identify all workers who will be working on the site during the Project.
- B. Provide the name and telephone number of the Contractor's Superintendent and authorized alternate individual who can be reached on a 24-hour basis at the Preconstruction Meeting.

- C. After Beneficial Occupancy, Contractors working inside those areas of the project shall display SI- provided ID badges and sign - in and – out at the zoo police station and other appropriate security checkpoints.

1.13 DRILLING, WELDING, TORCH, AND ARC CUTTING, AND OPERATIONS THAT PRODUCE AIRBORNE CONTAMINANTS

- A. Daily Permit: When welding, torch or arc cutting, or other heating operations are to occur inside existing structures, the Contractor shall obtain a daily “Burn Permit.” When work produces dust or other airborne contaminants, e.g., spray painting that could impair existing fire suppression or detection system(s), the Contractor shall obtain a daily “Fire System Impairment Permit.” Each permit must be obtained at least two working days in advance from the Building Manager’s Office through the COTR and posted at the job site prior to beginning the scheduled work.
- B. Fire Watch: No welding, torch, or arc cutting shall be performed unless adequate fire protection is provided. The Contractor shall maintain a fire watch for the duration of welding, cutting, and heating operations and for at least 30 minutes after the ‘hot’ work has stopped. A fire extinguisher (minimum 10 pounds, dry-chemical type, typical) shall be on hand when drilling, welding, or cutting.
- C. In lieu of SI’s Daily Permit, the Contractor may request the use of Contractor’s job site oversight permit process, confirming that it meets all SI oversight and safety requirements.

1.14 SAFETY

- A. All operations shall be conducted in accordance with all national and local fire and safety codes, laws, rules, and regulations.
- B. Warning Signs and Barricades: All roadways shall remain open to the public unless approved by the COTR. The Contractor shall provide, erect, and maintain all necessary signs, barricades, traffic cones, warning and danger signals and signs, and provide enough security guards and flaggers to insure the safe flow of traffic, protection of the work area and the safety of the public and staff.

1.15 SPECIFICATION, DRAWING CONVENTIONS, AND ELECTRONIC DATA

- A. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
 1. Imperative mood and streamlined language are generally used in the Specifications. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.
 2. Specification requirements are to be performed by Contractor unless specifically stated otherwise.
- B. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.
- C. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on the Drawings to identify materials and products:

1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.
2. Abbreviations: Materials and products are identified by abbreviations published as part of the U.S. National CAD Standard and scheduled on Drawings.
3. Keynoting: Materials and products are identified by reference keynotes referencing Specification Section numbers found in this Project Manual.

1.16 MISCELLANEOUS PROVISIONS

- A. Units of Measure: Perform all layout, construction, fabrication, and installation in accordance with the units of measure given in the Contract Documents. This project may be designed, dimensioned, and specified as an imperial project.
 1. All Contractor and sub-contractor personnel working on the site shall possess and use appropriate measuring equipment for all work shown. Conversion of dimensions shown on contract documents for use of non-compliant measuring equipment is prohibited.
 2. All submittals shall display appropriate measurements to ensure conformance with the Contract Documents. Project-specific shop drawings shall be prepared in preferred appropriate drawing scales and shall display appropriate dimensions.
 3. All correspondence shall use appropriate units exclusively. All cost data submitted by the Contractor in a proposal or any other submission shall be in appropriate units.
 4. All Operations and Maintenance (O&M) material shall be submitted with appropriate units and dimensions that clearly demonstrate conformance with the contract drawings and specifications.
 5. When permits or approvals are required by outside state or local agencies and/or utilities, provide submittals to these authorities in the format, scale, and measurement system they require. Annotate these submittals with parenthetical equivalents of critical size and location dimensions to facilitate the review of the submittal in comparison to the Contract Documents.
- B. Hazardous Materials: Notify the COTR immediately if any suspected asbestos-containing materials, lead paint, PCBs, or other hazardous materials other than those indicated in the construction documents are uncovered during Work.

1.17 CONSTRUCTION APPROVAL

- A. Final approval and direction shall be provided by the Contracting Officer (CO) or Contracting Officer's Technical Representative-Construction Management (herein COTR). The Authority Having Jurisdiction is SI-Office of Safety, Health, and Environmental Management (OSHEM) and they shall provide direction through the CO or COTR. The owner's agent is the COTR. All references within the construction documents to other entities providing approval shall mean initial approval or recommendation prior to COTR final approval.

END OF SECTION 011000

SECTION 01 2300 – ALTERNATES / OPTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contract Documents in their entirety, including the Drawings, Specifications, Construction Contract Clauses, and any other documents issued as part of the Contract, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for alternates/options.

1.3 DEFINITIONS

- A. Alternate/Option: An amount proposed by bidders and stated on the Bid Form for certain work defined in the bidding requirements that may be added to or deducted from the base bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.
 - 1. Alternates/Options described in this Section are part of the Work only if enumerated in the Agreement.
 - 2. The cost or credit for each alternate/option is the net addition to or deduction from the Contract Sum to incorporate alternate/option into the Work. No other adjustments are made to the Contract Sum.

1.4 PROCEDURES

- A. Coordination: Revise or adjust affected adjacent work as necessary to completely integrate work of the alternate/option into Project.
 - 1. Include as part of each alternate/option, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate/option.
- B. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate/option. Indicate if alternates/options have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated revisions to alternates/options.
- C. Execute accepted alternates/options under the same conditions as other work of the Contract.
- D. Schedule: A schedule of alternates/options is included at the end of this Section. Drawings and Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate/option.

END OF SECTION 012300

SECTION 01 2500 - SUBSTITUTION PROCEDURES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for substitutions.
- B. Related Requirements:
 - 1. Section 016000 "Product Requirements" for requirements for submitting comparable product submittals for products by listed manufacturers.

1.3 DEFINITIONS

- A. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.
 - 1. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
 - 2. Substitutions for Convenience: Changes proposed by Contractor or COTR that are not required in order to meet other Project requirements but may offer advantage to Contractor or COTR.

1.4 ACTION SUBMITTALS

- A. Substitution Requests: Submit each request electronically in Portable Document Format (.pdf) to the COTR for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.
 - 1. Substitution Request Form: Use CSI Form 13.1A or similar document information wise.
 - 2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
 - a. Statement indicating why specified product or fabrication, or installation cannot be provided, if applicable.
 - b. Coordination information, including a list of changes or revisions needed to other parts of the Work and to construction performed by COTR and separate Contractors that will be necessary to accommodate proposed substitution.
 - c. Detailed comparison of significant qualities of proposed substitution with those of the Work specified.
 - d. Include annotated copy of applicable Specification Section.
 - e. Significant qualities may include attributes such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.
 - f. Product Data, including drawings and descriptions of products and fabrication

- and installation procedures.
 - g. Samples, where applicable or requested.
 - h. Certificates and qualification data, where applicable or requested.
 - i. List of similar installations for completed projects with project names and addresses and names and addresses of architects and COTRs.
 - j. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
 - k. Research reports evidencing compliance with building code in effect for project, from ICC-ES.
 - l. Detailed comparison of Contractor's construction schedule using proposed substitution with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
 - m. Cost information, including a proposal of change, if any, in the Contract Sum.
 - n. Contractor's certification that proposed substitution complies with requirements in the Contract Documents except as indicated in substitution request, is compatible with related materials, and is appropriate for applications indicated.
 - o. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
3. If necessary, COTR will request additional information or documentation for evaluation within seven days of receipt of a request for substitution. COTR will notify Contractor of acceptance or rejection of proposed substitution within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.
- a. Forms of Acceptance: Change Order, Construction Change Directive, or Architect's Supplemental Instructions for minor changes in the Work.
 - b. Use product specified if COTR does not issue a decision on use of a proposed substitution within time allocated.

1.5 QUALITY ASSURANCE

- A. Compatibility of Substitutions: Investigate and document compatibility of proposed substitution with related products and materials. Engage a qualified testing agency to perform compatibility tests recommended by manufacturers.

1.6 PROCEDURES

- A. Coordination: Revise or adjust affected work as necessary to integrate work of the approved substitutions.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

- A. Substitutions for Cause: Submit requests for substitution immediately on discovery of need for change, but not later than 15 days prior to time required for preparation and review of related submittals.

- 1. Conditions: COTR will consider Contractor's request for substitution when the following

conditions are satisfied. If the following conditions are not satisfied, COTR will return requests without action, except to record noncompliance with these requirements:

- a. Requested substitution is consistent with the Contract Documents and will produce indicated results.
- b. Substitution request is fully documented and properly submitted.
- c. Requested substitution will not adversely affect Contractor's construction schedule. e. Requested substitution has received necessary approvals of authorities having Jurisdiction.
- d. Requested substitution is compatible with other portions of the Work.
- e. Requested substitution has been coordinated with other portions of the Work. h. Requested substitution provides specified warranty.
- f. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is Compatible with other products, and is acceptable to all contractors involved.

B. Substitutions for Convenience: Not allowed

PART 3 - EXECUTION (Not Used)

END OF SECTION 012500

FOR REFERENCE ONLY

SECTION 01 2600 - CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for handling and processing Contract modifications.
- B. Related Requirements:
 - 1. Section 012500 "Substitution Procedures" for administrative procedures for handling requests for substitutions made after the Contract award.

1.3 MINOR CHANGES IN THE WORK

- A. COTR will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or the Contract Time, on AIA Document G710, "Architect's Supplemental Instructions" (ASI).

1.4 PROPOSAL REQUESTS

- A. The Smithsonian Institution-Initiated Proposal Requests: COTR will issue a detailed description of proposed changes in the Work that may require adjustment to the Contract Sum or the Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications.
 - 1. Work Change Proposal Requests issued by COTR are not instructions either to stop work in progress or to execute the proposed change.
 - 2. As detailed in the proposed change request letter, submit a proposal noting the sum and the duration if any, necessary to execute the change.
 - a. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.
 - b. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
 - c. Include costs of labor and supervision directly attributable to the change.
 - d. Include an updated Contractor's construction schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an Extension of the Contract Time.
- B. Contractor-Initiated Proposals: If latent or changed conditions require modifications to the Contract, Contractor may initiate a claim by submitting a request for a change to COTR.

1. Include a statement outlining reasons for the change and the effect of the change on the Work. Provide a complete description of the proposed change. Indicate the effect of the proposed change on the Contract Sum and the Contract Time.
2. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.
3. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
4. Include costs of labor and supervision directly attributable to the change.
5. Include an updated Contractor's construction schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.
6. Comply with requirements in Section 012500 "Substitution Procedures" if the proposed change requires substitution of one product or system for product or system specified.

1.5 ADMINISTRATIVE CHANGE ORDERS

- A. Allowance Adjustment: See Section 012100 "Allowances" for administrative procedures for preparation of Change Order Proposal for adjusting the Contract Sum to reflect actual costs of allowances.

1.6 CHANGE ORDER PROCEDURES

- A. After the COTR approval of a Proposal Request, the Change Order is submitted to the Office of Contracting for processing.

1.7 CONSTRUCTION CHANGE DIRECTIVE

- A. Construction Change Directive: COTR may issue a Construction Change Directive. Construction Change Directive instructs Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order.
 1. Construction Change Directive contains a complete description of change in the Work. It also designates method to be followed to determine change in the Contract Sum or the Contract Time.

PART 2 - PRODUCTS (Not Used)

PART 3 – EXECUTION (Not Used)

END OF SECTION 012600

SECTION 01 2900 - PAYMENT PROCEDURES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment.
- B. Related Requirements:
1. Section 012600 "Contract Modification Procedures" for administrative procedures for handling changes to the Contract.
 2. Section 013200 "Construction Progress Documentation" for administrative requirements governing the preparation and submittal of the Contractor's construction schedule.
 4. The Smithsonian Institution Provided Supplemental Contract Documents.

1.3 DEFINITIONS

- A. Schedule of Values: A statement furnished by Contractor allocating portions of the Contract Sum to various portions of the Work and used as the basis for reviewing the Contractor's Applications for Payment.

1.4 SCHEDULE OF VALUES

- A. Coordination: Coordinate preparation of the schedule of values with preparation of Contractor's construction schedule.
1. Coordinate line items in the schedule of values with other required administrative forms and schedules, including the following:
 - a. Application for Payment forms with continuation sheets.
 - b. Submittal schedule.
 - c. Items required to be indicated as separate activities in Contractor's construction schedule.
 2. Submit the schedule of values to COTR at earliest possible date, but no later than seven Days before the date scheduled for submittal of initial Applications for Payment.
- B. Format and Content: Use Specifications table of contents as a guide to establish line items for the schedule of values. Provide at least one line item for each Specification Section.
1. Identification: Include the following Project identification on the schedule of values:
 - a. Project name and location.
 - b. Contractor's name and address.
 - c. Date of submittal.

- d. Smithsonian Facilities Project Number
 - e. Construction Contract Number
2. Arrange the schedule of values in tabular form with separate columns to indicate the following for each item listed:
- a. Related Specification Section or Division.
 - b. Description of the Work.
 - c. Change Orders (numbers) that affect value.
 - d. Dollar value of the following, as a percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.
 - 1) Labor.
 - 2) Materials.
 - 3) Equipment.
3. Provide a breakdown of the Contract Sum in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Coordinate with Specifications table of contents. Provide multiple line items for principal subcontract amounts in excess of 1 percent of the Contract Sum.
- a. Include separate line items under Contractor and principal subcontracts for and other Project closeout requirements in an amount totaling five percent of the Contract Sum and subcontract amount.
4. Round amounts to nearest whole dollar; total shall equal the Contract Sum.
5. Provide a separate line item in the schedule of values for each part of the Work where Applications for Payment may include materials or equipment purchased or fabricated and stored but not yet installed.
- a. Differentiate between items stored on-site and items stored off-site. If required, include evidence of insurance or bonded warehousing if required.
6. Provide separate line items in the schedule of values for initial cost of materials, for each subsequent stage of completion, and for total installed value of that part of the Work.
7. Each item in the schedule of values and Applications for Payment shall be complete.
- a. Temporary facilities and other major cost items that are not direct cost of actual work-in-place may be shown either as separate line items in the schedule of values or distributed as general overhead expense, at Contractor's option.
8. Schedule Updating: Update and resubmit the schedule of values before the next Applications for Payment when Change Orders or Construction Change Directives result in a change in the Contract Sum.

1.5 APPLICATIONS FOR PAYMENT

- A. Each Application for Payment following the initial Application for Payment shall be consistent with previous applications and payments as approved by the COTR. .
- B. Scheduling of the work: By the 25th of each month, inspect the work with the COTR to

determine percentages complete for each item, projected through the end of the month. In the event of a disagreement the COTR will determine the percentage complete.

- C. Payment Application Times: (By the last day of the month, submit an Application for Payment based on the determined percentages complete for each item)
- D. Application for Payment Forms: Use forms provided by The Smithsonian Institution for Applications for Payment.
- E. Application Preparation: Complete every entry on form. Execute by a person authorized to sign legal documents on behalf of the contractor. The COTR will return incomplete applications without action.
 - 1. Entries shall match data on the Schedule of Values and Contractor's Construction Schedule.
 - 2. Include the amounts of the Modifications executed before the last day of the construction period covered by application.
- F. Stored Materials: Include in Application for Payment the amounts applied for materials or equipment purchased or fabricated and stored but not yet installed. Differentiate between items stored on-site and items stored off-site.
 - 1. Provide certificate of insurance, evidence of transfer of title to The Smithsonian Institution, and consent of surety to payment, for stored materials.
 - 2. Billed Off-Site Material must comply with the applicable Federal Acquisition Regulations (FAR).
 - 3. Provide supporting documentation that verifies amount requested, such as paid invoices. Match amount requested with amounts indicated on documentation; do not include overhead and profit on stored materials.
 - 4. Provide summary documentation for stored materials indicating the following:
 - a. Value of materials previously stored and remaining stored as of date of previous Applications for Payment.
 - b. Value of previously stored materials put in place after date of previous Application for Payment and on or before date of current Application for Payment.
 - c. Value of materials stored since date of previous Application for Payment and remaining stored as of date of current Application for Payment.
- G. Electronic Submission: Submit signed original copies of each Application for Payment to COTR by a method ensuring receipt. One copy shall include waivers of lien and similar attachments if required.
 - 1. Attach one complete set of copies of certified weekly payroll data for the period covered by the Application for Payment.
 - 2. Attach the current and up to date Construction Progress Schedule.
 - 3. Attach a Change Order Status Report showing the following information for each approved Modification: Proposal Number, Modification Number (if applicable), affected activity numbers for each proposal, and the approved price for each Modification.
 - 4. Assignment of Claims: Assignment of Claims are subject to the approval of the Contracting Officer. Any Assignment of Claim or subsequent re-assignment shall meet the requirements of the Smithsonian Institution Contract Clause, "Assignment of Claims". All documents for assignments shall be written in the English language and display original ink signatures of the Contractor and the Assignee. All monies shall be in US dollars.
 - 5. Submit copies of Waste Diversion logs in accordance with Section 017419.
 - 6. Submit Construction Photos in accordance with section 013233.

- H. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:
1. List of subcontractors.
 2. Schedule of values.
 3. Contractor's construction schedule (preliminary if not final).
 4. Combined Contractor's construction schedule (preliminary if not final) incorporating Work of multiple contracts, with indication of acceptance of schedule by each Contractor.
 5. Products list (preliminary if not final).
 6. Submittal schedule (preliminary if not final).
 7. List of Contractor's staff assignments.
 8. List of Contractor's principal consultants.
 9. Copies of building permits.
 10. Copies of authorizations and licenses from authorities having jurisdiction for performance of the Work.
 11. Initial progress report.
 12. Report of preconstruction conference.
 13. Certificates of insurance and insurance policies.
 14. Performance and payment bonds.
 15. Data needed to acquire The Smithsonian Institution's insurance.
 16. Certified Payroll Documents.
- I. Final Payment Application: After completing Project closeout requirements, submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited, to the following:
1. Evidence of completion of Project closeout requirements.
 2. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.
 3. Updated final statement, accounting for final changes to the Contract Sum.
 4. Contractor's Affidavit of Release of Liens.
 5. Evidence that claims have been settled.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012900 SECTION 012900 - PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment.
- B. Related Requirements:
 - 1. Section 012600 "Contract Modification Procedures" for administrative procedures for handling changes to the Contract.
 - 2. Section 013200 "Construction Progress Documentation" for administrative requirements governing the preparation and submittal of the Contractor's construction schedule.
 - 4. The Smithsonian Institution Provided Supplemental Contract Documents.

1.3 DEFINITIONS

- A. Schedule of Values: A statement furnished by Contractor allocating portions of the Contract Sum to various portions of the Work and used as the basis for reviewing the Contractor's Applications for Payment.

1.4 SCHEDULE OF VALUES

- A. Coordination: Coordinate preparation of the schedule of values with preparation of Contractor's construction schedule.
 - 1. Coordinate line items in the schedule of values with other required administrative forms and schedules, including the following:
 - a. Application for Payment forms with continuation sheets.
 - b. Submittal schedule.
 - c. Items required to be indicated as separate activities in Contractor's construction schedule.
 - 2. Submit the schedule of values to COTR at earliest possible date, but no later than seven Days before the date scheduled for submittal of initial Applications for Payment.
- B. Format and Content: Use Specifications table of contents as a guide to establish line items for the schedule of values. Provide at least one line item for each Specification Section.
 - 1. Identification: Include the following Project identification on the schedule of values:
 - a. Project name and location.
 - b. Contractor's name and address.
 - c. Date of submittal.
 - d. Smithsonian Facilities Project Number
 - e. Construction Contract Number
 - 2. Arrange the schedule of values in tabular form with separate columns to indicate the following for each item listed:
 - a. Related Specification Section or Division.
 - b. Description of the Work.

- c. Change Orders (numbers) that affect value.
- d. Dollar value of the following, as a percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.
 - 1) Labor.
 - 2) Materials.
 - 3) Equipment.
- 3. Provide a breakdown of the Contract Sum in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Coordinate with Specifications table of contents. Provide multiple line items for principal subcontract amounts in excess of 1 percent of the Contract Sum.
 - a. Include separate line items under Contractor and principal subcontracts for and other Project closeout requirements in an amount totaling five percent of the Contract Sum and subcontract amount.
- 4. Round amounts to nearest whole dollar; total shall equal the Contract Sum.
- 5. Provide a separate line item in the schedule of values for each part of the Work where Applications for Payment may include materials or equipment purchased or fabricated and stored but not yet installed.
 - a. Differentiate between items stored on-site and items stored off-site. If required, include evidence of insurance or bonded warehousing if required.
- 6. Provide separate line items in the schedule of values for initial cost of materials, for each subsequent stage of completion, and for total installed value of that part of the Work.
- 7. Each item in the schedule of values and Applications for Payment shall be complete.
 - a. Temporary facilities and other major cost items that are not direct cost of actual work-in-place may be shown either as separate line items in the schedule of values or distributed as general overhead expense, at Contractor's option.
- 8. Schedule Updating: Update and resubmit the schedule of values before the next Applications for Payment when Change Orders or Construction Change Directives result in a change in the Contract Sum.

1.5 APPLICATIONS FOR PAYMENT

- A. Each Application for Payment following the initial Application for Payment shall be consistent with previous applications and payments as approved by the COTR. .
- B. Scheduling of the work: By the 25th of each month, inspect the work with the COTR to determine percentages complete for each item, projected through the end of the month. In the event of a disagreement the COTR will determine the percentage

complete.

- C. Payment Application Times: (By the last day of the month, submit an Application for Payment based on the determined percentages complete for each item)
- D. Application for Payment Forms: Use forms provided by The Smithsonian Institution for Applications for Payment.
- E. Application Preparation: Complete every entry on form. Execute by a person authorized to sign legal documents on behalf of the contractor. The COTR will return incomplete applications without action.
 - 1. Entries shall match data on the Schedule of Values and Contractor's Construction Schedule.
 - 2. Include the amounts of the Modifications executed before the last day of the construction period covered by application.
- F. Stored Materials: Include in Application for Payment the amounts applied for materials or equipment purchased or fabricated and stored but not yet installed. Differentiate between items stored on-site and items stored off-site.
 - 1. Provide certificate of insurance, evidence of transfer of title to The Smithsonian Institution, and consent of surety to payment, for stored materials.
 - 2. Billed Off-Site Material must comply with the applicable Federal Acquisition Regulations (FAR).
 - 3. Provide supporting documentation that verifies amount requested, such as paid invoices. Match amount requested with amounts indicated on documentation; do not include overhead and profit on stored materials.
 - 4. Provide summary documentation for stored materials indicating the following:
 - a. Value of materials previously stored and remaining stored as of date of previous Applications for Payment.
 - b. Value of previously stored materials put in place after date of previous Application for Payment and on or before date of current Application for Payment.
 - c. Value of materials stored since date of previous Application for Payment and remaining stored as of date of current Application for Payment.
- G. Electronic Submission: Submit signed original copies of each Application for Payment to COTR by a method ensuring receipt. One copy shall include waivers of lien and similar attachments if required.
 - 1. Attach one complete set of copies of certified weekly payroll data for the period covered by the Application for Payment.
 - 2. Attach the current and up to date Construction Progress Schedule.
 - 3. Attach a Change Order Status Report showing the following information for each approved Modification: Proposal Number, Modification Number (if applicable), affected activity numbers for each proposal, and the approved price for each Modification.
 - 4. Assignment of Claims: Assignment of Claims are subject to the approval of the Contracting Officer. Any Assignment of Claim or subsequent re-assignment shall meet the requirements of the Smithsonian Institution Contract Clause, "Assignment of Claims". All documents for assignments shall be written in the English language and display original ink signatures of the Contractor and the Assignee. All monies shall be in US dollars.
 - 5. Submit copies of Waste Diversion logs in accordance with Section 017419.

6. Submit Construction Photos in accordance with section 013233.
- H. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:
 1. List of subcontractors.
 2. Schedule of values.
 3. Contractor's construction schedule (preliminary if not final).
 4. Combined Contractor's construction schedule (preliminary if not final) incorporating Work of multiple contracts, with indication of acceptance of schedule by each Contractor.
 5. Products list (preliminary if not final).
 6. Submittal schedule (preliminary if not final).
 7. List of Contractor's staff assignments.
 8. List of Contractor's principal consultants.
 9. Copies of building permits.
 10. Copies of authorizations and licenses from authorities having jurisdiction for performance of the Work.
 11. Initial progress report.
 12. Report of preconstruction conference.
 13. Certificates of insurance and insurance policies.
 14. Performance and payment bonds.
 15. Data needed to acquire The Smithsonian Institution's insurance.
 16. Certified Payroll Documents.
- I. Final Payment Application: After completing Project closeout requirements, submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited, to the following:
 1. Evidence of completion of Project closeout requirements.
 2. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.
 3. Updated final statement, accounting for final changes to the Contract Sum.
 4. Contractor's Affidavit of Release of Liens.
 5. Evidence that claims have been settled.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012900

SECTION 01 3100 - PROJECT MANAGEMENT AND COORDINATION**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:
 - 1. General coordination procedures
- 2. Coordination, including items to Salvage and The SI Furnished Contractor Installed items
 - 3. Coordination drawings
 - 4. Requests for Information (RFIs)
 - 5. Project Web site
 - 6. Project meetings
 - 7. Conservation and Salvage
 - 8. Permits, Licenses, and Fees
 - 9. Pre-Condition Survey of the Site
 - 10. Equipment Coordination
- B. Each contractor shall participate in coordination requirements. Certain areas of responsibility are assigned to a specific contractor.
- C. Related Requirements:
 - 1. Division 01 Section 013200 "Construction Progress Documentation" for preparing and submitting the Contractor's Construction Schedule.
 - 2. Division 01 Section 013233 "Photographic Documentation" for preparing and submitting Pre-Condition of the Site Survey.
 - 3. Division 01 Section 013300 "Submittal Procedures" for submittal formats.
 - 4. Division 01 Section 015000 "Temporary Facilities and Controls" for additional Site Utilization Plan submittal requirements.
 - 5. Division 01 Section 017300 "Execution" for procedures for coordinating general installation and field- engineering services, including establishment of benchmarks and control points, coordination of the trades, and salvage.
 - 7. Division 01 Section 017700 "Closeout Procedures" for coordinating Contract closeout.
 - 8. Various sections of Divisions for specific coordination efforts between the trades.

1.3 COORDINATION

- A. Coordination: Coordinate design and construction operations included in various Sections of the Project Requirements and to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations, included in different Sections, which depend on each other for proper design, installation, connection, and operation.
- B. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
 - 1. Preparation of Contractor's Construction Schedule.

2. Preparation of the Schedule of Values.
 3. Installation and removal of temporary facilities and controls.
 4. Delivery and processing of submittals.
 5. Progress meetings.
 6. Pre-installation conferences.
 7. Project closeout activities.
- C. Correspondence: Correspond with the COTR for all matters related to this construction project, unless otherwise directed. Sign and date all correspondence and reference the project title, Smithsonian Project Number, and the Construction Contract Number.
- D. Conservation: Coordinate construction activities to ensure that operations are conducted with consideration given to conservation of energy, water, and materials.
- E. Salvage: Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work.
1. SI assumes no responsibility for salvage value or any loss or damage to materials or structures on the site for which the Contractor may have reflected a salvage value in the bid/offer except as specifically stated in the Contract Documents. Construction materials, equipment, or other items that are to be removed and neither re-used under this Contract nor reserved as property of SI, shall become the property of the Contractor. Remove from the premises and dispose of properly. Any items removed and sold by the Contractor cannot be identified being from the Smithsonian Institution and/or the National Zoo.
- F. Salvage: Salvage materials and equipment for The Smithsonian Institution Salvage items identified on drawings to be delivered to the Smithsonian Institution, including but not limited to the following:
1. Salvage and store items identified on drawings to be reinstalled as part of the Contractor's work,
- G. Permits, Licenses, and Fees: The Contractor is responsible for verifying all permitting requirements, fees, licenses, and estimated costs associated with the applicable local authorities and utilities. Keep the SI indemnified against all penalties and liability for breach of provisions of any national, or city ordinance, or law, and the regulations and by-laws of any local or other duly constituted authority which may be applicable to the Work, and with such rules and regulations of public bodies and companies.
- a. This is a federal project; federal projects are generally exempt from some permitting requirements. However, the following permits or costs are known to be required and are the responsibility of the Contractor: DC storm water management requirements, sediment and erosion control permit, off-site disposal, and transportation related permits, and permits related to asbestos and lead as applicable.
 - b. Obtain and pay for all applicable permits and licenses required by regulating agencies, including but not limited to permits for pedestrian and road markings and barricades, Construction fences, sidewalk cuts, utility company connections, elevator certificates, Waste containers, and other required items.
 - c. Pay all duties, fees, taxes, and other charges and file all notices necessary and incidental to the due and lawful execution of the Work.
 - d. Provide temporary constructions at the site as necessary to maintain safe access, if required, for persons with disabilities. All provisions for temporary access shall be Subject to the approval of the COTR.
- H. The Smithsonian Institution (SI) Furnished Contractor Installed Items and Installations:

1. The Contractor shall be responsible for coordinating and monitoring delivery, and for the installation of SI-Furnished items as part of the overall construction schedule.
2. The Contractor shall coordinate with standard procedures, special events, and other requirements imposed by SI/NZP.

1.4 SUBMITTALS

- A. Coordination Drawings: Prepare drawings to ensure building systems and components are compatible and fit together in the space available at appropriate tolerances.
 1. See Division 01 Section "Submittal Procedures" for information on preparation of Shop Drawings, formats, quantities, review requirements.
 2. See Division 01 Sections "Execution" and "Project Management and Coordination" for coordinated geometry and utility drawings.
- B. Site Utilization Plan: Develop a Site Utilization Plan discussing Contractor's proposed plan for working in and using the Premises for this project. Submit the Site Utilization Plan for approval no less than 5 working days prior to the Pre-construction Conference. No on-site work will be permitted until Contractor receives approval of the Site Utilization Plan. Address interactions with other agencies, contractors, tenants, the public, and any others reviewing this project and/or making use of the site and surrounding areas. Submit a Plan that both graphically and narratively describes at a minimum:
- C. Locations of overlap in use of the site by the Contractor and others, including work areas, delivery points, access/egress areas, staging and office space, if applicable
 1. Specific items of work by others required to support critical milestones in the Contractor's schedule.
 2. Completion or delivery of work by others that may impact the Contractor's schedule.
 3. Portions of the Work that create special hazards or disturbances.
 4. Portions of the Work that affect utilities, fire protection or detection systems, or security systems.
 5. Protection to be provided by the Contractor for work complete by others either before or during the Project.
 6. Coordination between all components and disciplines.
 7. Traffic control as required to maintain safe construction operation and safe pedestrian travel.
 8. Contractor staging area and their recommended solution to address contractor and staff areas of overlap.
 9. Traffic Control Plan for this area per Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, Federal Highway Administration, latest edition), including but not limited to proposed plans, durations, and methods for any lane closures, including certified flaggers, barriers, traffic signals, and safe passage of pedestrians near the construction site.
- D. Staff Names: Within 10 days after award of construction operations, submit a list of principal staff assignments, including project manager for construction, superintendent, and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home and office telephone numbers (see also Division 01 Section "Temporary Facilities and Controls"). Provide names, addresses, and telephone numbers of individuals assigned as standbys in the absence of individuals assigned to Project.
- E. Subcontract List: Within 30 days of starting construction operations, prepare and submit a written summary identifying individuals or firms proposed for each portion of the Work, including those

who are to furnish products or equipment fabricated to a special design.

1. Name, address, and telephone number of entities performing subcontract or supplying products.
2. Number and title of related Specification Section(s) covered by subcontract.
3. Drawing number and detail references, as appropriate, covered by subcontract.

- F. Key Personnel Names: Within 10 days of starting construction operations, submit a list of key personnel assignments, including Project Manager for construction, superintendent, and other personnel

in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and telephone numbers, including home, office, and cellular telephone numbers and e-mail addresses. Provide names, addresses, and telephone numbers of individuals assigned as alternates in the absence of individuals assigned to Project.

1. Post copies of list in project meeting room, in temporary field office, on Project Web site, and by each temporary telephone. Keep list current at all times.

1.5 PROJECT MEETINGS

- A. General: Schedule and conduct meetings and conferences at Project site, unless otherwise indicated.

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify COTR of scheduled meeting dates and times.
2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
3. Reporting: Record significant discussion and agreements achieved. Attach any updated schedules or other documentation discussed. Distribute the meeting minutes to everyone concerned. Copies for SI personnel and SI consultants shall be delivered to the COTR for distribution. Meeting minutes should be prepared within 5 working days of the meeting.

- B. Preconstruction Conference: The COTR will schedule a preconstruction conference before starting construction, at a time convenient to the Contractor, but no later than 10 working days after execution of the Agreement. The conference will be held at Project site or another convenient location at a time coordinated with the COTR. The COTR will conduct the meeting to review responsibilities and personnel assignments.

1. Attendees: Authorized representatives of the SI and COTR, Architect/Engineer, and their consultants; Contractor and its superintendent; major subcontractors; manufacturers; suppliers; and other concerned parties shall attend the conference. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Discuss items of significance that could affect progress, including the following:

- a. Contract Time: Construction Notice-to-Proceed date and Completion date.
- b. Tentative construction schedule. Phasing.
- c. Critical work sequencing.
- d. Dimensional controls and role of surveyor.
- e. Mobilization and Staging.
- f. Designation of responsible personnel; emergency procedures and phone numbers.
- g. Procedures for processing RFI's, field decisions, and Change Orders/Contract Modifications.
- h. Procedures for processing Applications for Payment.
- i. Distribution of the Contract Documents.
- j. Submittal procedures.
- k. Preparation of Record Documents.
- l. Use of the premises: utility interruptions; building systems interruptions, including

fire protection; accessibility requirements; preservation of vegetation, wildlife, and natural resources; responsibility for temporary facilities and controls; office, work, and storage areas; equipment deliveries and priorities; access to loading dock, haul routes, Contractor deliveries.

- m. Parking availability.
- n. First aid.
- o. Security and Fire Protection requirements.
- p. Progress cleaning and housekeeping.
- q. Pre-condition of the site survey.
- r. Rough-in inspections.
- s. Testing.
- t. Quality Assurance.
- u. Frequency and scheduling of Progress Meetings.

C. Pre-Submittal and Pre-installation Conferences: Conduct pre-submittal and pre-installation conferences at Project site before each coordinated shop drawing and construction activity that requires coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise the COTR of scheduled meeting dates.
2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:
 - a. Contract Documents.
 - b. Options.
 - c. Related Change Orders.
 - d. Purchases.
 - e. Deliveries.
 - f. Submittals.
 - g. Review of mockups.
 - h. Possible conflicts.
 - i. Compatibility problems.
 - j. Time schedules.
 - k. Weather limitations.
 - l. Manufacturer's written recommendations.
 - m. Warranty requirements.
 - n. Compatibility of materials.
 - o. Acceptability of substrates.
 - p. Temporary facilities and controls.
 - q. Space and access limitations.
 - r. Regulations of authorities having jurisdiction.
 - s. Testing and inspecting requirements.
 - t. Required performance results.
 - u. Protection of construction and personnel.
3. Record significant conference discussions, proposals, agreements, and disagreements.
4. Do not proceed with installation if the conference cannot be successfully concluded. Initiate whatever actions are necessary to resolve impediments to performance of the Work and reconvene the conference at earliest feasible date.

D. Progress Meetings: Conduct progress meetings at weekly intervals or as scheduled by COTR. Coordinate dates of meetings with preparation of payment requests. (Progress Meetings may evolve into Project Close-out Meetings at a mutually agreed-upon point in the project.)

1. Attendees: In addition to representatives of the SI, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
 2. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.
 - a. Safety issues or concerns.
 - b. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's Construction Schedule. Determine how construction behind schedule will be expedited, secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
 - c. Review present and future needs of each entity's present, including the following:
 - 1) Interface requirements.
 - 2) Dimensional and survey issues.
 - 3) Sequence of operations.
 - 4) Status of submittals & RFI's.
 - 5) Deliveries.
 - 6) Off-site fabrication.
 - 7) Access.
 - 8) Site utilization.
 - 9) Temporary facilities and controls.
 - 10) Work hours.
 - 11) Hazards and risks.
 - 12) Progress cleaning.
 - 13) Quality and work standards.
 - 14) Change Orders.
 - 15) Documentation of information for payment requests.
 3. Schedule Updating: Revise Contractor's Construction Schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.
- E. Special Topic and Coordination Meetings: Conduct special topic and coordination meetings when technical issues or immediate needs require them. Schedule time, place, and appropriate attendees with the COTR. Special topic and coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and pre-installation conferences. Provide minutes of meetings for distribution within 5 working days.
1. Fire Alarm Contractor shall walk the Project Site with the SI OSHM Fire Protection Engineer before proceeding with work to determine final mounting height and location for the exit signs.
 2. Animal care team meeting to review and select final locations of viewing ports in fence lines.
 3. Animal care team meeting to review and select final locations and arrangements of deadfall items.
- F. Monthly Executive Project Review Meetings: The COTR will conduct monthly executive meetings at the site established in the Preconstruction Conference for the purpose of briefing senior SI personnel on construction progress.
1. Attendees: In addition to representatives of the SI (as invited by the Contracting Officer and the COTR) and the Architect/Engineer, the Contractor's Project Manager, Superintendent, Quality Assurance Representative, Project Executive (as needed), other necessary

Contractor personnel, and major or otherwise critical subcontractor personnel, shall attend.

- a. Agenda: Review and correct or approve minutes of the previous meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.
- b. Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to Combined Contractor's Construction Schedule. Determine how construction behind schedule will be expedited; secure Commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
- c. Schedule Updating: Revise Combined Contractor's Construction Schedule after each coordination meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.
- d. Review present and future needs of each contractor present, including the following:
 - 1) Interface requirements between SI activities and construction activities.
 - 2) Special events.
 - 3) Access.
 - 4) Site utilization and security.
 - 5) Hazards and risks.
 - 6) Progress cleaning.
 - 7) Quality and work standards.
 - 8) Change Orders.
 - 9) Other items significant to the participants' responsibilities.
- e. Site Tours: Meetings may conclude with a tour of the construction site. Provide an authorized Contractor's representative to lead tour and ensure safety of participants.

1.6 PRE-CONDITION SURVEY OF THE SITE

- A. After the Preconstruction Meeting and prior to start of the Work on site, inspect the project site (i.e., Building, its contents, grounds, and equipment) with major subcontractors, the COTR and other SI personnel as required for the purpose of verification of the existing conditions. Any damages or defective equipment will be noted at this time, and this survey will serve as the basis for the establishment of the pre-construction conditions. The Contractor and the Smithsonian Institution will jointly establish the identification of pre-construction conditions. Written and Photographic Documentation: Prepare a typewritten and photographic report to identify damages or defects of materials, equipment, and/or the site, in accordance with the requirements in Division 01 Section "Photographic Documentation". Retain one report and submit one report electronically to the Contracting Officer and the COTR.
- B. Video Documentation: Video the observations made during the survey of the existing conditions for the buildings, improvements, finishes, utilities, interior surfaces, construction, and other systems, components, or materials which might be affected by the Work, including sidewalks, streets, and adjacent facilities, in accordance with the requirements in Division 01 Section "Photographic Documentation." Submit documentation electronically to the COTR.

1.7 PAINT COORDINATION

- A. Coordinate marking and painting of mechanical and electrical items. The COTR will provide a paint matrix for reference and coordination between systems.

1.8 COORDINATION DRAWINGS

- A. Coordination Drawings, General: Drawings prepared by Contractor which superimpose Work of several trades, including but not limited to architectural, structural, mechanical, plumbing, fire protection, fire alarm, and electrical Work. Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

- 1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

- a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe the relationship of various systems and components.
- b. Coordinate the addition of trade-specific information to the coordination drawings by multiple contractors in a sequence that best provides coordination of the information and resolution of conflicts between installed components before submitting for review.
- c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
- d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
- e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.
- f. Indicate required installation sequences.
- g. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to the COTR indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract. Contractor shall utilize GIS / CAD to capture all utilities within project site and shall adhere to ASCE/CI 75-22

- E. Review: COTR will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If COTR determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, the COTR will inform the Contractor, who shall make changes as directed and resubmit.

- 1. Coordination Drawing Prints: Prepare coordination drawing prints according to requirements in Section 013300 "Submittal Procedures."

- F. Special Design Considerations:

- 1. Locate any device requiring periodic maintenance or access in walls in non-public, non-animal areas or above accessible ceilings.

1.9 CONSTRUCTION LAYOUT

- A. Description of Work
 - 1. Furnish surveying and dimension control for Project.
 - 2. Locate per Civil Drawings. Maintain benchmarks throughout construction operations.
 - 3. Maintain central file of dimensional information that is updated weekly with information on actual field measurements.
 - 4. Lay out structural walls and major utilities.
- B. Contractor Responsibilities
 - 1. Contractor is responsible for properly laying out Work and for lines, measurements, and locations of Work.
 - 2. Contractor is responsible for coordinating actual field dimensions with subcontractors.
 - 3. Notify COTR of issues that arise related to actual dimensions of installed work and include proposed corrective measures.

1.10 REQUESTS FOR INFORMATION (RFIs)

- A. General: Immediately on discovery of the need for additional information or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.
 - 1. COTR will return RFIs submitted to Architect by other entities controlled by Contractor with no response.
 - 2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
- B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
 - 1. Project name.
 - 2. Project number.
 - 3. Date.
 - 4. Name of Contractor.
 - 5. RFI number, numbered sequentially.
 - 6. RFI subject.
 - 7. Specification Section number and title and related paragraphs, as appropriate.
 - 8. Drawing number and detail references, as appropriate.
 - 9. Field dimensions and conditions, as appropriate.
 - 10. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
 - 11. Contractor's signature.
 - 12. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
 - a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.
- C. COTR will review each RFI, determine action required, and respond. Allow ten working days response for each RFI.
 - 1. The following Contractor-generated RFIs will be returned without action:
 - a. Requests for approval of submittals.
 - b. Requests for approval of substitutions.
 - c. Requests for approval of Contractor's means and methods.

- d. Requests for coordination information already indicated in the Contract Documents.
 - e. Requests for adjustments in the Contract Time or the Contract Sum.
 - f. Requests for interpretation of The COTR's actions on submittals.
 - g. Incomplete RFIs or inaccurately prepared RFIs.
 - 2. COTR action on RFIs that may result in a change to the Contract Time, or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."
 - a. If the RFI response warrants change in the Contract Time or the Contract Sum, notify COTR in writing within 2 days of receipt of the RFI response.
 - D. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly. Use software log that is part of Project Web site. Include the following Software log with not less than the following:
 - 1. Project name.
 - 2. Name and address of Contractor.
 - 3. RFI number including RFIs that were returned without action or withdrawn.
 - 4. RFI description.
 - 5. Date the RFI was submitted.
 - 6. Date COTR response was received.
 - E. On receipt of COTR action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify COTR within 24 hours if Contractor disagrees with response.
 - 1. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
 - 2. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.
- 1.11 PROJECT WEB SITE
- A. Contractor's Project Web site for purposes of hosting and managing project communication and documentation until Final Completion. Project Web site shall include the following functions:
 - 1. Project directory.
 - 2. Project correspondence.
 - 3. Meeting minutes.
 - 4. Contract modifications forms and logs.
 - 5. RFI forms and logs.
 - 6. Task and issue management.
 - 7. Photo documentation.
 - 8. Schedule and calendar management.
 - 9. Submittals forms and logs.
 - 10. Payment application forms.
 - 11. Drawing and specification document hosting, viewing, and updating.
 - 12. Online document collaboration.
 - 13. Reminder and tracking functions.
 - 14. Archiving functions.
 - 15. Procore or equal.
 - B. Provide up to 15 Project Web site user licenses for use of the Smithsonian Institution, The Smithsonian Institution's Commissioning Authority, Construction Manager, Architect, and Architect's consultants. Provide eight hours of software training on site office for Project Web site users.

- C. On completion of Project, provide **one** complete archive copy of all Project Web files in PDF and original document format.
1. Attendees: Authorized representatives of The Smithsonian Institution, The Smithsonian Institution's Commissioning Authority, Construction Manager, Architect, and their consultants; Contractor and its superintendent and LEED coordinator; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
 2. Closeout Conference: Contractor shall schedule and conduct a project closeout conference, at a time convenient to The Smithsonian Institution and Architect.
 3. Conduct the conference to review requirements and responsibilities related to Project closeout.
 4. Attendees: Authorized representatives of The Smithsonian Institution, The Smithsonian Institution's Commissioning Authority, Construction Manager, Architect, and their consultants; Contractor and its Superintendent; major subcontractors; suppliers; and other concerned parties shall attend the meeting. Participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
 5. Agenda: Discuss items of significance that could affect or delay Project closeout, including:
 - a. Preparation of record documents.
 - b. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
 - c. Submittal of written warranties.
 - e. Requirements for preparing operations and maintenance data.
 - f. Requirements for delivery of material samples, attic stock, and spare parts.
 - g. Requirements for demonstration and training.
 - h. Preparation of Contractor's punch list.
 - i. Procedures for processing Applications for Payment for final payment.
 - j. Submittal procedures.
 - k. Coordination of separate contracts.
 - l. The Smithsonian Institution's partial occupancy requirements.
 - m. Installation of The Smithsonian Institution's furniture, fixtures, and equipment.
 - n. Responsibility for removing temporary facilities and controls.
 6. Minutes: Entity conducting meeting will record and distribute meeting minutes. Revise "Progress Meetings" Paragraph below if Project requires holding progress meetings at different intervals. Insert special intervals such as "every third Tuesday" to suit special circumstances.
- F. Coordination Meetings: Conduct Project coordination meetings at required intervals. Project coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and pre-installation conferences.
1. Attendees: In addition to representatives of the COTR, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meetings shall be familiar with Project and authorized to conclude matters relating to the Work.
 2. Agenda: Review and correct or approve minutes of the previous coordination meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of project.
 - a. Combined Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to combined Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure

commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.

3. Contractor's Monthly Presentation to The Smithsonian Institution's Senior Leadership:
 - a. Standing Meeting

Date - TBD

Location: NZP Visitor's Center Board Room

- b. Prepare and present a 10 - 15- minute PowerPoint presentation reviewing current progress of the project.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013100

FOR REFERENCE ONLY

SECTION 01 3200 - CONSTRUCTION PROGRESS DOCUMENTATION**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including the following:
1. Startup construction schedule.
 2. Contractor's construction schedule.
 3. Construction schedule updating reports.
 4. Daily construction reports.
 5. Material location reports.
 6. Site condition reports.
 7. Special reports.
- B. Related Requirements:
1. Section 013300 "Submittal Procedures" for submitting schedules and reports.
 2. Section 014000 "Quality Requirements" for submitting a schedule of tests and inspections.

1.3 DEFINITIONS

- A. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities included in a construction schedule consume time and resources.
1. Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.
 2. Predecessor Activity: An activity that precedes another activity in the network.
 3. Successor Activity: An activity that follows another activity in the network.
- B. Cost Loading: The allocation of the schedule of values for the completion of an activity as scheduled. The sum of costs for all activities must equal the total Contract Sum unless otherwise approved by Architect.
- C. CPM: Critical path method, which is a method of planning and scheduling a construction project where activities are arranged based on activity relationships. Network calculations determine when activities can be performed and the critical path of Project.
- D. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project duration and contains no float.
- E. Event: The starting or ending point of an activity.
- F. Float: The measure of leeway in starting and completing an activity.

1. Float time is not for the exclusive use or benefit of either Owner or Contractor, but is a jointly owned, expiring Project resource available to both parties as needed to meet schedule milestones and Contract completion date.
 2. Free float is the amount of time an activity can be delayed without adversely affecting the early start of the successor activity.
 3. Total float is the measure of leeway in starting or completing an activity without adversely Affecting the planned Project completion date.
- G. Resource Loading: The allocation of manpower and equipment necessary for the completion of an activity as scheduled.
- 1.4 INFORMATIONAL SUBMITTALS
- A. Format for Submittals: Submit required submittals in the following format:
1. Working electronic copy of schedule file, where indicated.
 2. PDF electronic file.
- B. Startup construction schedule.
1. Approval of cost-loaded, startup construction schedule will not constitute approval of schedule of values for cost-loaded activities.
- C. Startup Network Diagram: Of size required to display entire network for entire construction period. Show logic ties for activities.
- D. Contractor's Construction Schedule: Initial schedule, of size required to display entire schedule for entire construction period.
1. Submit a working electronic copy of schedule, using software indicated, and labeled to comply with requirements for submittals. Include type of schedule (initial or updated) and date on label.
- E. CPM Reports: Concurrent with CPM schedule, submit each of the following reports. Format for each activity in reports shall contain activity number, activity description, cost and resource loading, original duration, remaining duration, early start date, early finish date, late start date, late finish date, and total float in calendar days.
1. Activity Report: List of all activities sorted by activity number and then early start date, or actual start date if known.
 2. Logic Report: List of preceding and succeeding activities for all activities, sorted in ascending order by activity number and then early start date, or actual start date if known.
 3. Total Float Report: List of all activities sorted in ascending order of total float.
- F. Construction Schedule Updating Reports: Submit with Applications for
- Payment. G. Daily Construction Reports: Submit at weekly intervals.
- H. Material Location Reports: Submit at monthly intervals.
- I. Site Condition Reports: Submit at time of discovery of differing conditions.

- J. Special Reports: Submit at time of unusual event.
- K. Qualification Data: For scheduling consultant.

1.5 QUALITY ASSURANCE

- A. Scheduling Consultant Qualifications: An experienced specialist in CPM scheduling and reporting, with capability of producing CPM reports and diagrams within 24 hours of COTR's request.
- A. Prescheduling Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to the preliminary construction schedule and Contractor's construction schedule, including, but not limited to, the following:
 1. Review software limitations and content and format for reports.
 2. Verify availability of qualified personnel needed to develop and update schedule.
 3. Discuss constraints, including phasing, work stages, area separations, interim milestones and partial Owner occupancy and site use.
 4. Review submittal requirements and procedures.
 5. Review time required for review of submittals and resubmittals.
 6. Review requirements for tests and inspections by independent testing and inspecting agencies.
 7. Review time required for Project closeout and Owner startup procedures, including commissioning activities.
 8. Review and finalize list of construction activities to be included in schedule.
 9. Review procedures for updating schedule.

1.6 COORDINATION

- A. Coordinate Contractor's construction schedule with the schedule of values submittal schedule, progress reports, payment requests, and other required schedules and reports.
 1. Secure time commitments for performing critical elements of the Work from entities involved.
 2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

PART 2 - PRODUCTS

2.1 CONTRACTOR'S CONSTRUCTION SCHEDULE, GENERAL

- A. Time Frame: Extend schedule from date established for commencement of the Work and/or the Notice to Proceed (indicate both if different), to date of final completion.
 1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date, unless specifically authorized by Change Order.
- B. Activities: Treat each story or separate area as a separate numbered activity for each main element of the Work. Comply with the following:
 1. Activity Duration: Define activities so no activity is longer than 20 days, unless specifically allowed by the COTR.
 2. Procurement Activities: Include procurement process activities for the following long lead items and major items, requiring a cycle of more than 60 days, as separate activities in Schedule. Procurement cycle activities include, but are not limited to, submittals, approvals, purchasing, fabrication, and delivery.

3. Submittal Review Time: Include review and resubmittal times indicated in Section 013300 "Submittal Procedures" in schedule. Coordinate submittal review times in Contractor's construction schedule with submittal schedule.
 4. Startup and Testing Time: Include no fewer than 14 days for startup and testing.
 5. Punch List and Final Completion: Include not more than **30** days for completion of punch list items and final completion.
- C. Constraints: Include constraints and work restrictions indicated in the Contract Documents and as follows in schedule and show how the sequence of the Work is affected.
1. Phasing: Arrange list of activities on schedule by phase.
 2. Work under More Than One Contract: Include a separate activity for each contract.
 3. Work by Owner: Include a separate activity for each portion of the Work performed by Owner.
 4. Products Ordered in Advance: Include a separate activity for each product. Include delivery date indicated in Section 011000 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
 5. Owner-Furnished Products: Include a separate activity for each product. Include delivery date indicated in Section 011000 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
 6. Work Restrictions: Show the effect of the following items on the schedule:
 - a. Coordination with existing construction.
 - b. Limitations of continued occupancies.
 - c. Uninterruptible services.
 - d. Partial occupancy before Substantial Completion.
 - e. Use of premises restrictions.
 - f. Provisions for future construction.
 - g. Seasonal variations.
 - h. Environmental control.
 - i. NZP Special Events Impacting Site Access
 - j. Government Holidays
 7. Work Stages: Indicate important stages of construction for each major portion of the Work, including but not limited to, the following:
 - a. Subcontract awards.
 - b. Submittals.
 - c. Purchases.
 - d. Mockups.
 - e. Fabrication.
 - f. Sample testing.
 - g. Deliveries.
 - h. Installation.
 - i. Tests and inspections.
 - j. Adjusting.
 - k. Curing.
 - l. Building flush-out.
 - m. Startup and placement into final use and operation.
 - n. establishment of planting
 8. Construction Areas: Identify each major area of construction for each major portion of the Work. Indicate where each construction activity within a major area must be sequenced or integrated with other construction activities to provide for the following:
 - a. Structural completion.
 - b. Temporary enclosure and space conditioning.
 - c. Permanent space enclosure.
 - d. Completion of mechanical installation.

- e. Completion of electrical installation.
 - f. Substantial Completion.
- D. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Substantial Completion, and final completion.
- E. Upcoming Work Summary: Prepare summary report indicating activities scheduled to occur or commence prior to submittal of next schedule update. Summarize the following issues:
- 1. Unresolved issues.
 - 2. Unanswered Requests for Information.
 - 3. Rejected or unreturned submittals.
 - 4. Notations on returned submittals.
 - 5. Pending modifications affecting the Work and Contract Time.
- F. Recovery Schedule: When periodic update indicates the Work is 7 or more calendar days behind the current approved schedule, submit a separate recovery schedule indicating means by which Contractor intends to regain compliance with the schedule. Indicate changes to working hours, working days, crew sizes, and equipment required to achieve compliance, and date by which recovery will be accomplished.
- H Computer Scheduling Software: Prepare schedules using current version of a program that has been developed specifically to manage construction schedules.

2.2 CONTRACTOR'S CONSTRUCTION SCHEDULE (CPM SCHEDULE)

- A. General: Prepare network diagrams using AON (activity-on-node) format.
- B. Startup Network Diagram: Submit diagram within 14 days of date established for the Notice to Proceed. Outline significant construction activities for the first 90 days of construction.
- C. CPM Schedule: Prepare Contractor's construction schedule using a cost- and resource-loaded, time-scaled CPM network analysis diagram for the Work.
- 1. Develop network diagram in sufficient time to submit CPM schedule so it can be accepted for use no later than 60 days after date established for the Notice to Proceed.
 - a. Failure to include any work item required for performance of this Contract shall not excuse Contractor from completing all work within applicable completion dates, regardless of Architect's approval of the schedule.
 - 2. Conduct educational workshops to train and inform key Project personnel, including subcontractors' personnel, in proper methods of providing data and using CPM schedule information.
 - 3. Establish procedures for monitoring and updating CPM schedule and for reporting progress. Coordinate procedures with progress meeting and payment request dates.
 - 4. Use "one workday" as the unit of time for individual activities. Indicate nonworking days and holidays incorporated into the schedule to coordinate with the Contract Time.
- D. CPM Schedule Preparation: Prepare a list of all activities required to complete the Work. Using the startup network diagram, prepare a skeleton network to identify probable critical paths.
- 1. Activities: Indicate the estimated time duration, sequence requirements, and relationship of each activity in relation to other activities. Include estimated time frames for the

following activities:

- a. Preparation and processing of submittals.
 - b. Mobilization and demobilization.
 - c. Purchase of materials.
 - d. Delivery.
 - e. Fabrication.
 - f. Utility interruptions.
 - g. Installation.
 - h. Work by Owner that may affect or be affected by Contractor's activities.
 - i. Testing and commissioning.
 - j. Punch list and final completion.
 - k. Activities occurring following final completion.
2. Critical Path Activities: Identify critical path activities, including those for interim completion dates. Scheduled start and completion dates shall be consistent with Contract milestone dates.
 3. Processing: Process data to produce output data on a computer-drawn, time-scaled network. Revise data, reorganize activity sequences, and reproduce as often as necessary to produce the CPM schedule within the limitations of the Contract Time.
 4. Format: Mark the critical path. Locate the critical path near center of network; locate paths with most float near the edges.
 - a. Sub networks on separate sheets are permissible for activities clearly off the critical path.
 5. Cost- and Resource-Loading of CPM Schedule: Assign cost to construction activities on the CPM schedule. Do not assign costs to submittal activities. Obtain Architect's approval prior to assigning costs to fabrication and delivery activities. Assign costs under main subcontracts for testing and commissioning activities, operation and maintenance manuals, punch list activities, Project record documents.
- E. Contract Modifications: For each proposed contract modification and concurrent with its submission, prepare a time-impact analysis using a network fragment to demonstrate the effect of the proposed change on the overall project schedule.
- F. Initial Issue of Schedule: Prepare initial network diagram from a sorted activity list indicating straight "early start-total float." Identify critical activities. Prepare tabulated reports showing the following:
1. Contractor or subcontractor and the Work or activity.
 2. Description of activity.
 3. Main events of activity.
 4. Immediate preceding and succeeding activities.
 5. Early and late start dates.
 6. Early and late finish dates.
 7. Activity duration in workdays.
 8. Total float or slack time.
 9. Average size of workforce.
 10. Dollar value of activity (coordinated with the schedule of values).
- G. Schedule Updating: Concurrent with making revisions to schedule, prepare tabulated reports showing the following:
1. Identification of activities that have changed.
 2. Changes in early and late start dates.
 3. Changes in early and late finish dates.
 4. Changes in activity durations in workdays.
 5. Changes in the critical path.

6. Changes in total float or slack time.
 7. Changes in the Contract Time.
- H. Value Summaries: Prepare two cumulative value lists, sorted by finish dates.
1. In first list, tabulate activity number, early finish date, dollar value, and cumulative dollar value.
 2. In second list, tabulate activity number, late finish date, dollar value, and cumulative dollar value.
 3. In subsequent issues of both lists, substitute actual finish dates for activities completed as of list date.
 4. Prepare list for ease of comparison with payment requests, coordinate timing with progress meetings.
 - a. In both value summary lists, tabulate "actual percent complete" and "cumulative value completed" with total at bottom.
 - b. Submit value summary printouts before each regular scheduled progress meeting.

2.3 REPORTS

- A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at Project site:
1. List of subcontractors at Project site.
 2. List of separate contractors at Project site.
 3. Approximate count of personnel at Project site.
 4. Equipment at Project site.
 5. Material deliveries.
 6. High and low temperatures and general weather conditions, including presence of rain or snow.
 7. Accidents.
 8. Meetings and significant decisions.
 9. Unusual events (see special reports).
 10. Stoppages, delays, shortages, and losses.
 11. Meter readings and similar recordings.
 12. Emergency procedures.
 13. Orders and requests of authorities having jurisdiction.
 14. Change Orders received and implemented.
 15. Change Directives received and implemented.
 16. Services connected and disconnected.
 17. Equipment or system tests and startups.
 18. Partial completions and occupancies.
 19. Substantial Completions authorized.
- B. Material Location Reports: At monthly intervals, prepare and submit a comprehensive list of materials delivered to and stored at Project site. List shall be cumulative, showing materials previously reported plus items recently delivered. Include with list a statement of progress on and delivery dates for materials or items of equipment fabricated or stored away from Project site. Indicate the following categories for stored materials:
1. Material stored prior to previous report and remaining in storage.
 2. Material stored prior to previous report and since removed from storage and installed.
 3. Material stored following previous report and remaining in storage.
- C. Site Condition Reports: Immediately on discovery of a difference between site conditions and the Contract Documents, prepare and submit a detailed report. Submit with a Request for Information. Include a detailed description of the differing conditions, together with recommendations for changing the Contract Documents.

2.4 SPECIAL REPORTS

- A. General: Submit special reports directly to Owner within **one** day of an occurrence. Distribute copies of report to parties affected by the occurrence.
- B. Reporting Unusual Events: When an event of an unusual and significant nature occurs at Project site, whether or not related directly to the work, prepare and submit a special report. List chain of events, persons participating, and response by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

PART 3 - EXECUTION

3.1 CONTRACTOR'S CONSTRUCTION SCHEDULE

- A. Scheduling Consultant: Engage a consultant to provide planning, evaluation, and reporting using CPM scheduling.
 - 1. In-House Option: Owner may waive the requirement to retain a consultant if Contractor employs skilled personnel with experience in CPM scheduling and reporting techniques. Submit qualifications.
 - 2. Meetings: Scheduling consultant shall attend all meetings related to Project progress, alleged delays, and time impact.
- B. Contractor's Construction Schedule Updating: At monthly intervals, update schedule to reflect actual construction progress and activities. Issue before each regularly scheduled progress meeting.
 - 1. Revise schedule immediately after each meeting or other activity where revisions have been recognized or made. Issue updated schedule concurrently with the report of each such meeting.
 - 2. Include a report with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
 - 3. As the Work progresses, indicate final completion percentage for each activity.
- C. Distribution: Distribute copies of approved schedule to COTR, separate contractors, testing and inspecting agencies, and other parties identified by Contractor with a need-to-know schedule responsibility.
 - 1. Post copies in Project meeting rooms and temporary field offices.
 - 2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction Activities.

END OF SECTION 013200

SECTION 01 3233 - PHOTOGRAPHIC DOCUMENTATION**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. The Contract Documents in their entirety, including the Drawings, Specifications, Construction Contract Clauses, and any other documents issued as part of the Contract, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for the following:
1. Preconstruction photographs.
 2. Periodic construction photographs.
 3. Final completion construction photographs.
 4. Preconstruction video recordings.
 5. Periodic construction video recordings.
 6. Web-based construction photographic documentation.
- B. Related Requirements:
1. Section 013300 "Submittal Procedures" for submitting photographic documentation.
 2. Section 017700 "Closeout Procedures" for submitting photographic documentation as project record documents at Project closeout.
 3. Section 017900 "Demonstration and Training" for submitting video recordings of demonstration of equipment and training of Owner's personnel.
 4. Section 024119 "Selective Structure Demolition" for photographic documentation before selective demolition operations commence.
 5. Section 311000 "Site Clearing" for photographic documentation before site clearing Operations commence.

1.3 SUBMITTALS

- A. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names, and addresses of architects and owners, and other specified information.
- B. Key Plan: Submit key plan of Project site and building with notation of vantage points marked for location and direction of each **photograph**. Indicate elevation or story of construction. Include same information as corresponding photographic documentation.
- C. Construction Photographs: Submit one digital file of each photographic view within ten working days of taking photographs.
1. All images, digital media, contact sheets, photographs, and negatives, including the copyright thereto, are the sole property of the Smithsonian Institution and shall be submitted to the COTR before Final Payment processing. The Contractor shall not use Smithsonian Institution property except as authorized in writing by the Contracting Officer.
 2. Digital Images: Submit a complete set of digital image electronic files. Identify electronic media with date photographs were taken. Submit images that have the same aspect ratio as the sensor, un-cropped.
 3. Submit a minimum of 10 digital photo files per week.

1.4. QUALITY ASSURANCE

- A. Photographer Qualifications: An individual with advanced camera skills and professional quality equipment.

1.5. COORDINATION

- A. Auxiliary Services: Cooperate with the photographer and provide auxiliary services requested, including access to Project site and use of temporary facilities including temporary lighting.

PART 2 - PRODUCTS

2.1 PHOTOGRAPHIC MEDIA

- A. Digital Images: Provide images in JPEG format, with minimum sensor size of 8 megapixels format transmitted electronically to the COTR.

PART 3 - EXECUTION

3.1 CONSTRUCTION PHOTOGRAPHS

- A. Pre-construction Photographs: Before starting construction, take color photographs of project site and surrounding areas from different vantage points, as directed by the COTR. This will serve as the basis for the establishment of pre-construction conditions. See also Division 01 Section "Project Management and Coordination", Article 1.6.
 - 1. Take photographs to show existing conditions adjacent to the property before starting the Work.
 - 2. Identify damages or defects of materials, equipment, and the site. Retain one copy and submit one copy to the COTR electronically.
- B. Periodic Construction Photographs: Take a minimum of 10 color photographs per week, with timing each month adjusted to coincide with the cutoff date associated with each Application for Payment. The actual number and location of views shall be directed by the COTR. Take photographs at the start and finish of various construction activities as directed by the COTR. Select vantage points to best show status of construction and progress since the last photographs were taken.
- C. Final Completion Construction Photographs: The COTR will discuss with the photographer for desired vantage points.
 - 1. Upon completion of the project, provide pictures of the entire project documenting all of the project's highlights and features.
- D. All references to photo documentation is for electronic format submissions. All documentation submitted will become the property of SI for SI's duplication and distribution.

END OF SECTION 013233

SECTION 01 3250 - BUILDING INFORMATION MODELING (BIM) REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements for Building Information Modeling including, but not limited to, the following:
 - 1. Development of BIM Execution Plan.
 - 2. Development of Construction Model(s).
 - 3. Development of Fabrication/Shop Drawings at Contractor's option.
 - 4. Development of Coordination Model(s).
 - 5. Development of Coordination Report.
 - 6. As-Built Model(s) and Drawings.
- B. Related Requirements:
 - 1. Division 01 section Operation and Maintenance Data for Facility Asset Data Requirements.
- C. Contractor's Responsibility:
 - 1. Develop deliverables required in this Section.
 - 2. Contractor is solely responsible for the quality and accuracy of all documentation and submittals of this Section.
 - 3. The intent of BIM deliverables is to avoid interference and conflicts, optimize construction sequencing, achieve greater efficiencies in cost estimating and project coordination, and ensure access for maintenance, replacement, or repairs.
 - a. Coordination: Contractor is solely responsible for the coordination of facility systems and equipment.
 - b. Construction sequencing: Contractor is solely responsible to sequence construction activities to facilitate the fabrication and installation of systems and equipment without interference, conflicts, or delays in construction, and providing adequate access to effectively maintain and replace systems and equipment.
- D. Existing Documents: The following building information, obtained and developed by the Architect and/or Engineer during the design phase, may be available to the Contractor:
 - 1. Design Intent Model(s) (.rvt, .ifc, & .nws / .nwd)
 - 2. Contract Documents (.pdf)
 - 3. CAD Files (.dwg)
 - 4. Point Clouds (.rcs)
 - 5. Scans of the original building design drawings (.pdf)
 - 6. BIM PxP (.docx, .pdf)
 - 7. LOD Matrix(.xlsx, .pdf)
- E. SI BIM Practice Requirements:
 - 1. The following documents related to are available on the Smithsonian A/E Information Center website, under the SI Design Standards (SDS) section and are applicable to BIM requirements:
 - a. Smithsonian OPDC BIM Guidelines: Describes information, procedures, and responsibilities relevant to BIM work completed by architecture, engineering, and construction (AEC) consultants in order to assure accurate and consistent deliverables.

- b. OPDC Revit Templates: BIM templates developed by Smithsonian OPDC are available for the Contractor to use when utilizing Autodesk Revit as the model authoring software to populate with accurate project-specific facility asset data.
 - 1) Scope of required facility data is described in the template and should be modified to reflect actual Project requirements.
- c. OPDC Revit Template Users Guide: This document, prepared by Smithsonian OPDC, describes how to incorporate and “OPDC Revit Templates” and develop the project BIM.
- d. OPDC BIM Project Execution Plan (PxP): Template document that defines the expected BIM deliverables and guides the coordination of the project team, throughout the project lifecycle.

1.2 DEFINITIONS

- A. As-Built Model: Building Information Model(s) developed by the Contractor that represents the installed condition of facility elements.
- B. Building Information Model (BIM): A digital representation of physical and functional characteristics of a facility.
- C. BIM Project Execution Plan (PxP): A document prepared by the contractor, utilizing a standard OPDC PxP template that defines the expected BIM deliverables and guides the coordination of the project team, throughout the project lifecycle.
- D. Construction Model: Building Information Model(s) that demonstrates and communicates the facility data necessary to procure, fabricate, schedule or construct the Project.
- E. Coordination: A process implemented to ensure the efficiency and harmony of the relationship of facility elements. Typically performed in a BIM environment by evaluating interferences, also called “clash detection”.
- F. Coordination Model: Building Information Model(s) that demonstrates and communicates the spatial relationship of facility elements.
- G. Coordination Report: A report developed to communicate and demonstrate that the facility elements have been properly coordinated and identify areas where issues may still exist.
- H. Design Intent Model: Building Information Model(s) that demonstrates and communicates the creative objectives of the designer.
- I. Fabrication/Shop Drawing: Drawing generated by the contractor from a Construction Model based on the contract documents that communicates the information necessary to fabricate facility elements. Fabrication/Shop Drawings typically contain one system and are intended for use of trade personnel to fabricate, assemble, and install facility elements.
- J. Facility Breakdown Structure: a system-oriented hierarchical decomposition of a facility into smaller components. Typically, the facility breakdown structure is based on disciplines, trades, described by Master Format.
- K. Facility Asset Data: Non-graphical information attached to an object in a Building Information Model that defines various characteristics of an object.

- L. Furnishings: Built-in or movable cabinets, casework, seating, or other appurtenances provided by the Contractor.
- M. Interference: Spatial conflict between facility elements.
- N. Level of Development: Describes the minimum dimensional, spatial, quantitative, qualitative, and other data includes in a model element as defined in the OPDC BIM Guidelines.
- O. Level of Accuracy: Describes the minimum dimensional accuracy of element(s) as defined in the OPDC BIM Guidelines.
- P. Conformed Model – Updates the Design Intent Model for those aspects maintained by the designer to record authorized design changes during construction.

1.3 SUBMITTALS

- A. BIM Project Execution Plan (PxP): Prepare and submit a plan utilizing the “OPDC BIM Execution Plan” framework document available on the Smithsonian Architectural-Engineer Information Center website. Submit the PxP in Portable Document Format (PDF) within 60 days after contract award. BIM Project Execution Plan (PxP) shall be updated as required and submitted with Final As-Built Model(s).
- B. Submit plans, sections, and other review documents monthly, in .pdf format. To include field changes that affect the accuracy of the Construction and As-Built Models.
- C. Construction Model(s): Prepare and submit, on a quarterly basis, Construction Model(s) that contain spaces, objects and data required to purchase, fabricate, and install project elements. Graphically indicate construction progress in Construction Model(s). Construction Model(s) are to be submitted with all Coordination Model(s) link into one central model using Autodesk Navisworks with all disciplines.
- D. Coordination Model(s): Prepare and submit Coordination Model(s) on a monthly basis. Coordination Model(s) are to be based on the facility breakdown structure of the Design Intent Model. Contractors are to perform all work utilizing 3D modeling software in order to facilitate seamless coordination with BIM workflows and file integration. All design elements should be produced three-dimensionally in programs that can output file formats supported by Autodesk Navisworks. Coordination Model(s) are to be submitted using Autodesk Navisworks with all disciplines.
 - 1. Coordination Model(s) are to be submitted prior to fabrication, and installation of any element within the area represented within the Coordination Model(s).
 - 2. Fabrication/Shop Drawings and Construction Model(s) are to be integrated into the Coordination Model(s) or otherwise referenced in the Coordination Model(s).
- E. CAD Drawings. Export CAD documents from the BIM authoring application in a format conforming to SI requirements. Reference the “OPDC Revit Template Users Guide” and “OPDC CAD Guidelines”.
- F. Coordination Report: Prepare and submit a written Coordination Report generated from the Coordination Model(s) prior to fabrication, and installation of any facility element within the area represented within the Coordination Model(s).
 - 1. Coordination Report is to be submitted in Portable Document Format (PDF).

- G. Final As-Built Model(s): After installation of all Facility Elements, update and submit As-Built Model(s) to document the condition of the facility upon completion of construction. As-Built Models are to be submitted with all Model(s) and link into one central model using Autodesk Navisworks with all disciplines.
- H. As-Built Fabrication/Shop Drawings: After installation of all Facility Elements, update and submit Fabrication/Shop Drawings to document the condition of the facility upon completion of construction.
- I. By submitting the As-Built Model(s) and Coordination Report(s), the Contractor confirms that the following have been accomplished:
1. Existing and As-Built conditions have been adequately identified, documented, and field verified.
 2. Facility elements are properly represented within the Model(s) to align with field verified conditions.
 3. Access to maintain, repair, or replace facility elements has been identified and validated.
 4. Clearances, such as those required by code and equipment specifications, have been identified and validated.
 5. Interferences have been identified and resolved.
- J. Data Capture (Laser Scan): Survey, prepare and submit Point Cloud files at key stages during the construction process including but not limited to: post-demo, open trenches, rough-in / close-in, project completion, etc. as directed by COTR. This survey to be utilized to ensure all As-Built conditions for the project are documented properly. This will include establishing the necessary Survey Control Network throughout the site and scanning as many points as may be required to create a reliable point cloud of all interior and exterior surfaces of the building. The required object surface density of scanning shall be a minimum of 6 mm (1/4"). RGB color shall be mapped to both the exterior and interior scans. Point Cloud data should be broken into separate data sets as directed by COTR and be registered in the same coordinate frame (origin point) as the As-Built Model(s). Point cloud data to be submitted using Autodesk Recap.

PART 2 - EXECUTION

2.1 CONTRACT DOCUMENTS AND DESIGN INTENT MODEL(S)

- A. The Contract Documents and Design Intent Model(s) will be provided to the Contractor for reference in the development of the Construction and Coordination Model(s) and Fabrication/Shop drawings. The Contract Documents and Design Intent Model(s) communicate creative objectives of the Architect and/or Engineer and are not intended to be used for fabrication and construction of the facility in that the size, arrangement, and level of development of facility elements may not have the necessary tolerances to allow for fabrication.
- B. The Contract Documents are the binding document(s) of record, the Design Intent Model(s) are provided for reference only.

2.2 DEVELOPMENT OF BUILDING INFORMATION MODELING PLAN (BIM PxP)

- A. The BIM PxP shall be approved by SI prior to development of Construction / Coordination Model(s), and development of Facility Asset Data. Information contained in the BIM PxP shall conform to the "OPDC BIM Guidelines".

2.3 INSPECTION OF EXISTING CONDITIONS

- A. Prior to the development of the Construction / Coordination Model(s), inspect and verify accuracy of information communicated in the Contract Documents and Design Intent Model with respect to the existing conditions. Notify COTR if any conflicts among Contract Documents, the Design Intent Model, and existing conditions are discovered. Do not proceed with development of Construction / Coordination Model(s) until conflicts are resolved to the satisfaction of SI.

2.4 FACILITY ASSET DATA

- A. See spec 01 section OPERATION AND MAINTENANCE DATA for asset data requirements
- B. The Contractor is responsible for incorporating Design Intent Model and Facility Asset Data Spreadsheet revisions into the Construction and As-Built Model(s) in order to maintain an up-to-date basis for Building Information Modeling throughout construction.
- C. Contractor is responsible for incorporating the following Asset Data from SI Facility Asset Data Spreadsheet into the Construction and As-Built Model(s):
 - 1. Asset ID# (SI will provide)
 - 2. Asset Name (SI will provide)
 - 3. SpecID (CSI Master Format 2016)
 - 4. Manufacturer
 - 5. Description

2.5 DEVELOPMENT OF CONSTRUCTION MODEL(S)

- A. The intent of the Construction Model(s) is to communicate the necessary information to construct the facility including size, location, and arrangement of both existing to remain and new elements and to incorporate the as-built conditions.
- B. Develop Construction Model(s) based upon Contract Documents, Design Intent Model(s), and verified existing conditions.
- C. Construction Model(s) shall accurately reflect the geometry and details of existing and new elements within the facility.
 - 1. Use manufacturer or custom model elements to accurately reflect the components detailed in documents submitted for approval.
 - 2. Update the model elements to accurately reflect any revisions to geometry or details arising from the submittal review process.
- D. Construction Model(s) are to have a consistent origin that can be referenced to a real world datum or benchmark, located as required in the "OPDC Revit Template Users' Guide".
- E. Quality Control. The Construction Model(s) will undergo automated model checks utilizing rulesets, as described in the "OPDC BIM Guidelines" document and visual review by SI.
- F. The Construction Model(s) are to reflect all necessary access and clearances.
- G. The Construction Model(s) will include, but not be limited to, the following elements with all necessary intelligence included to produce plans, sections, elevations, riser diagrams, and schedules as applicable:

1. Substructure: All foundations, subgrade enclosures, slabs-on-grade, and water and gas utility connections. Substructure elements shall be depicted with all necessary recesses, curbs, pads, slopes, closure pours, expansion/construction joints, and major penetrations depict-ed.
2. Shell: All superstructure, exterior vertical enclosures, and exterior horizontal enclosures, including a depiction of expansion/construction joints.
 - a. Superstructure: All columns, primary and secondary framing members, and bracing for the roof and floor systems (including decks).
 - b. Exterior Vertical Enclosures: Exterior vertical enclosures shall be depicted to the exact height, length, width, and ratings (thermal, acoustic, fire) to properly reflect element types. Exterior windows, doors and grilles including hardware sets, louvers and vents, and wall appurtenances shall be depicted to represent their actual size, type and location.
3. Interiors: All interior partitions, windows, doors and grilles, louvers, and vents, raised floors, and ceilings, depicted to represent their exact location, height, length, width, and ratings (thermal, acoustic, fire) to properly reflect element types.
4. Services: All elevators, escalators, plumbing, HVAC, fire protection, electrical, communications, electronic safety and security, and integrated automation elements, including all major openings and penetrations, cable trays, cable bundles and pipe grouping. All clearances and insulation shall be accounted for in the model for use in interference management and maintenance access requirements. Nonpermanent items are not required to be modeled or contain facility data.
 - a. Plumbing: All plumbing elements including plumbing piping and fixture layouts, floor and area drains, and related equipment.
 - b. Heating, Ventilation, And Air Conditioning (HVAC): All heating, ventilation, and air conditioning (HVAC) elements including piping, valves, ductwork fixture lay-outs and related equipment.
 - c. Fire Protection: All fire protection elements including piping, valves, and related equipment.
 - d. Electrical: All electrical elements including conduit, fixture layouts and related equipment (including power for systems furniture).
 - e. Communications: All communications and low voltage systems elements including conduit and related equipment.
 - f. Security: All Electronic Safety and Security elements including conduit and related equipment.
 - g. Integrated Automation: All integrated automation elements including conduit and related equipment.
 - h. Model all elements larger than 38mm (1-1/2 inch) in diameter for any trade. When equal or smaller element are grouped or run in a uniform path. That group of elements shall be modeled when larger than 152mm (6 inches).
5. Equipment and Furnishings: All fixed equipment and furnishings, depicted to represent their exact location, height, length, width, configuration, materials, finishes, and mechanical and electrical requirements.
6. Special Construction and Demolition: All special construction and demolition including special construction, facility remediation and demolition
7. Sitework: All sitework elements, including site improvements, liquid and gas utilities, electrical site improvements, and site communications.

- H. Construction Model(s) must be revised and certified by the Contractor prior to installation of facility elements contained within the models.

2.6 DEVELOPMENT OF COORDINATION MODEL(S)

- A. Develop Coordination Model(s) that combine facility elements contained within the Construction Models with other facility elements depicted in the Design Intent Model to review the efficiency and harmony of the relationship of the facility elements.
- B. Verify that all facility elements are properly represented within the Construction and Coordination Model(s) prior to coordination.
- C. Conduct the following interferences checks to ensure that there are no conflicts in the installation of facility elements.
 - 1. Substructure/Shell vs Interiors
 - 2. Substructure/Shell vs Equipment and Furnishings provided by Contractor
 - 3. Interiors vs Equipment and Furnishings provided by Contractor.
 - 4. Substructure vs. Shell
 - 5. Services vs other components:
 - a. Services vs Substructure/Shell
 - b. Services vs Interiors
 - c. Services vs Equipment and Furnishing
 - d. Services vs Site work
 - 6. Services
 - a. Plumbing vs HVAC
 - b. Plumbing vs Fire Protection
 - c. Plumbing vs Electrical
 - d. Plumbing vs Communications
 - e. Plumbing vs Electronic Safety and Security
 - f. HVAC vs Fire Protection
 - g. HVAC vs Electrical
 - h. HVAC vs Communications
 - i. HVAC vs Electronic Safety and Security
 - j. Fire Protection vs Electrical
 - k. Fire Protection vs Communications
 - l. Fire Protection vs Electronic Safety and Security
 - m. Electrical vs Communications
 - n. Electrical vs Electronic Safety and Security
 - o. Communications vs Electronic Safety and Security
 - 7. ADA Accessibility
- D. Coordination Model(s) shall be free of interferences prior to installation of any associated facility element.
- E. Update the Coordination Model(s) to reflect changes throughout construction prior to installation of any associated facility element.

2.7 COORDINATION REPORT(S)

- A. Develop Coordination Reports identifying outstanding issues after the development of the Coordination Model(s), including but not limited to:
 - 1. Clashes:
 - a. Itemize number of clashes.
 - b. Clash Category
 - c. Describe clashes.

- d. Describe the resolution of clashes and other conflicts.
2. Design changes.
3. Differing site conditions.
4. Hazardous or safety related issues.
5. Assets installed and assets pending installation.

- B. The report shall be organized by CSI Master Format 2016 specification section or by trade
- C. The issues identified within the Coordination Report are to be addressed by the **Contractor** in consultation with the SI and the Architect / Engineer prior to installation of facility elements.
- D. The Contractor is solely responsible for the cost of remedying any clashes that could have been discovered during the clash detection process.

2.8 INSTALLATION

- A. Install facility elements in accordance with approved Construction Model(s), Fabrication/Shop Drawings, Coordination Model(s), and Coordination Reports. Any variance from these documents shall require approval by the SI C O T R prior to the installation of the associated facility elements.
- B. Adjust Coordination Model(s) throughout construction to reflect all changes made to the approved Contract Drawings and Specs, Design Intent Model, and Fabrication/Shop Drawings.
- C. Maintain an up-to-date Fabrication/Shop Drawing set and Coordination Model(s) for all parties to access.

2.9 AS-BUILT MODEL AND DRAWINGS

- A. Upon completion of the installation of facility elements, update and deliver As-Built Model(s) and Fabrication/Shop Drawings to document the condition of the facility upon completion of construction.
 1. The updated Construction and Coordination Model(s) are considered the As-Built Model for this facility. These models shall clearly indicate portions of the facility that are constructed and portions where construction is pending.
 2. As-Built Model(s) shall be field verified for accuracy and updated as required. The Level of Development (LOD) shall be LOD 500
 3. The Level of Accuracy (LOA) of the model(s) shall be minimal 12mm (1/2") for existing and align with construction tolerances for all new construction (minimal 24mm (1")).
 4. Model(s), CAD and SI-GIS exports are to be delivered in native file formats as well as file formats and naming conventions consistent with SI standards. Reference the "OPDC Revit Templates Users Guide" and "Smithsonian OPDC BIM Guidelines" guidance documents.
 5. All models shall be linked and submitted using Autodesk Navisworks.

END OF SECTION 01 3250

SECTION 01 3300 - SUBMITTAL PROCEDURES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. The Contract Documents in their entirety, including the Drawings, Specifications, Construction Contract Clauses, and any other documents issued as part of the Contract, apply to this Section. All submittal documentation shall be submitted in a PDF format plus program file and hard copies as requested.

1.2 SUMMARY

- A. Section includes requirements for the submittal schedule and administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.
- B. Related Requirements:
 - 1. Division 01 Section 012500 "Substitution Procedures" and "Product Requirements" for substitutions.
 - 2. Division 01 Section 012900 "Payment Procedures" for submitting Applications for Payment.
 - 3. Division 01 Section 013100 "Project Management and Coordination" for submitting reports and coordination drawings.
 - 4. Division 01 Section 013200 "Construction Progress Documentation" for submitting schedules and reports, including Contractor's Construction Schedule Submittals Schedule.
 - 5. Division 01 Section 013233 "Photographic Documentation" for submitting construction photographs.
 - 6. Division 01 Section 014000 "Quality Requirements" certifications and for erecting mockups.
 - 7. Division 01 Section 017700 "Closeout Procedures" for submitting warranties.
 - 8. Division 01 Section 017839 "Project Record Documents" for submitting Record Drawings,

Record Specifications and Record Product Data.

1.3 DEFINITIONS

- A. Shop Drawings: Detailed drawings, schedules, diagrams, and illustrations prepared specifically for this project by the Contractor, or any subcontractor, manufacturer, supplier, or distributor to illustrate fabrication and/or installation of a portion of the Work.
- B. Schedule: A detailed tabulation of components, items, or parts to be furnished for use on this project.
- C. Statement: An affirmation prepared by the Contractor, the installer, or manufacturer of a material, product, or system, to satisfy a requirement defined in a technical section.
- D. Factory Test Report: A written report of the findings of a test performed by the Contractor on an actual portion of the Work or prototype prepared for this project before it is shipped to the site.
- E. Field Test Report: A written report of the findings of a test performed by the Contractor on a portion of the Work during or after installation.
- F. Certificate of Compliance: A written statement, signed by an authorized official of the manufacturer of a product or system or supplier of a material attesting that the product, system, or material meets the requirements of the contract documents. The certificate of compliance

must be dated after the award of this Contract and must name the project and cite the specification section, paragraph, and requirements which it is intended to address.

- G. Product Data: Illustrations, standard schedules, performance charts, instructions, brochures, diagrams, manufacturer's descriptive literature, and catalog information illustrating a material, product, or system to be installed on this project.
- H. Color Charts: Pre-printed brochures showing the color range of a material.
- I. Test Reports: Reports verifying that a material, assembly, system, process, or laboratory meets requirements established in the Contract Documents. Reports shall indicate compliance by naming and describing the test method and test results. Testing must have occurred within three years of the date of award of this contract.
- J. Samples:
 - 1. Physical examples of materials, equipment, assemblies, or workmanship establishing standards for evaluating finished Work.
 - 2. Color/Texture Selection Sample ("range set"): Samples of an available range of textures and/or colors of a material formed of the actual finish material over a substrate identical to that which will be used in the field.
- K. Testing Mock-Ups:
 - 1. Provide full scale assemblies of components specified as test specimens. Simulate actual construction conditions as accurately as possible.
 - 2. Provide extra materials required to replace any which fail during tests, except intentional failure tests beyond specified performance requirements. Provide sufficient stock of Replacement materials at test site to complete tests without delay.
 - 3. See relevant Specification Sections for testing requirements.
 - 4. Shipping mock-up to test site:
 - a. Assemble test specimens in shop to verify completeness and adequacy.
 - b. Dismantle test specimens and ship to test site using same packing, loading procedures and mode of transportation as used for components shipped directly to Project site.
 - 5. Assembling mock-ups at test site:
 - a. Retain same installer as will be assembling components at project site to assemble test specimens at test site.
 - b. When possible, use personnel assigned to Project site to do assembly.
- L. Sample Panels:
 - 1. A sample panel specially erected near Project site or, upon COTR's approval or direction, at a remote location that incorporates several specified materials.
 - 2. Sample panels display color range, texture, bond, joinery, tolerances, mortar color and workmanship expected of materials incorporated in Work.
 - 3. Sample panels will be used by COTR for final material selection.
 - 4. Maintain approved sample panels in good condition until completion of relevant work and use as standard for work.
 - 5. Remove sample panels from project site at completion of project.
- M. Shop Production Samples:
 - 1. A sample panel specially erected at fabricator's shop that incorporates specified materials or

components.

2. Construct shop production samples prior to commencing fabrication of component.
3. Shop production samples display color range, texture, bond, joinery, fabrication tolerances, mortar color and workmanship expected of materials incorporated in work.
4. Maintain approved shop production samples in good condition until completion of relevant work and use as standard for work.
5. Finished and maintained shop production samples may be incorporated into work.

N. Mockups (Sample Installations):

1. Definition: A partial installation of selected materials for COTR's approval of workmanship, installation tolerances and visual acceptance of materials.
2. Construct mockups prior to pre-installation conferences.
3. Maintain mockups during construction as a standard for work.
4. Finished and maintained mockups may be incorporated into work, unless they are specifically indicated to be removed from project site at completion of project.

O. Material Safety Data Sheets: Instructions, warnings, and recommended and required handling and use procedures for individual hazardous materials published by the product manufacturer.

1.4 SUBMITTALS

A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual specification sections. Types of submittals are indicated in individual specification sections.

1. The Contractor shall provide electronic submittals as PDF electronic files directly to the COTR for distribution to the A/E team. See below for hard copy requirements.
2. The COTR will return a memorandum containing applicable comments with an annotated file, if applicable.
3. The Contractor is to annotate and retain one copy of the file as an electronic project record.

B. Certificates and certifications submittals: Provide a statement that includes the signature of the entity responsible for preparing the certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

C. Construction Drawings: Prepare and submit on a bi-weekly basis. Files shall be submitted in CAD / GIS format. Construction drawings shall contain objects and data required to purchase, fabricate, and install project elements and graphically indicate construction progress.

D. As-Built Drawings: After installation of all elements, update and submit As-Built drawings to document the condition of the facility upon completion of construction. Files shall be submitted in CAD / GIS format. In addition, SI expects to receive final approved PDF As-Built Drawings electronically.

E. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for Coordination. The COTR reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
3. Submittals shall be complete for each Specification Section in order to be considered

for Review by the COTR, with the exception of installation and post-installation tests and reports. Incomplete submittals will be rejected by the COTR.

- F. Submittals Schedule and Control Log: Comply with requirements in Division 01 Section "Construction Progress Documentation" for list of submittals and time requirements for scheduled performance of related construction activities.
- G. Processing Time: Allow enough time for submittal review, including time for re-submittals, as follows. Time for review shall commence on the COTR's receipt of submittal.
1. Initial Review: Allow 15 working days for initial review of each submittal. Allow additional time if processing must be delayed permitting coordination with subsequent submittals. The COTR will advise Contractor when a submittal being processed must be delayed for coordination.
 2. If intermediate submittal is necessary, process it in same manner as initial submittal.
 3. Allow 10 working days for each re-submittal.
 4. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including time for Resubmission of items which are initially rejected due to improper submission or non-Compliance with the Contract Documents.
 5. Provide COTR with 2 weeks' notice of proposed visits to remote sites to review shop production samples.
- H. Identification: Place a permanent label or title block on each submittal for identification.
1. Indicate name of firm or entity that prepared each submittal on label or title block.
 2. Provide adequate space on label or beside title block to record Contractor's review and approval markings, COTR/Engineer's submittal stamp, and the COTR's submittal stamp. On submittals requiring delegated-design responsibility, provide room for Professional Engineer's stamp and signature.
 3. Include the following information on label for:
 - a. Project name.
 - b. Project Number.
 - c. Date.
 - d. Name and address of Contractor.
 - e. Name and address of subcontractor.
 - f. Name and address of supplier.
 - g. Name of manufacturer.
 - h. Unique identifier, including revision number.
 - i. Specification Section number, title, and full paragraph number of appropriate specifications.
 - j. Drawing number and detail references, as appropriate.
 - k. Other necessary identification.
- I. Deviations: Highlight, encircle, or otherwise identify deviations from the Contract Documents on submittals.
- J. Requests for Substitutions: Submit requests for substitutions for items identified by manufacturer, brand name, make, catalog number, etc. in the Construction Documents, in accordance with the Smithsonian Institution Construction Contract Clauses. After award of the Contract, Contractor requests for substitutions may be considered and accepted by the SI at the discretion of the Contracting Officer. See also Division 01 Section "Product Requirements."
- K. Additional Copies: Unless additional copies are required for final submittal, and unless COTR observes noncompliance with provisions of the Contract Documents, initial submittal may serve

as final submittal.

- L. Transmittal: Package each submittal individually and appropriately for transmittal and handling. Transmit each submittal using a transmittal form. COTR will discard submittals received from sources other than Contractor.
1. On an attached separate sheet, prepared on Contractor's letterhead, record relevant information, requests for data, revisions other than those requested by the COTR on previous submittals, and deviations from requirements of the Contract Documents, including minor variations and limitations. Include the same label information as the related submittal.
 2. Include Contractor's certification stating that information submitted complies with requirements of the Contract Documents.
 3. Transmittal Form: Provide locations on form for the following information:
 - a. Project name.
 - b. Date.
 - c. Destination (To:).
 - d. Source (From:).
 - e. Names of subcontractor, manufacturer, and supplier.
 - f. Category, type, and number of submittals.
 - g. Submittal purpose and description.
 - h. Submittal and transmittal distribution record.
 - i. Remarks.
 - j. Signature of transmitter.
 - k. Quality certification, certifying submittal meets all Contract Document requirements.
- M. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, and installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.
- N. Use for Construction: Use only final submittals with mark indicating action taken by the COTR in connection with construction.

PART 2 - PRODUCTS

2.1 SUBMITTAL PROCEDURES

- A. General Submittal Procedure Requirements: Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
1. Post electronic submittals as PDF electronic files directly to Project Website specifically established for project.
 - a. COTR will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.
 2. Submit electronic submittals via email as PDF electronic files.
 - a. COTR will return annotated file. Annotate and retain one copy of file as an electronic Project record document file.
 3. Certificates and Certifications Submittals: Provide a statement that includes signature of

entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity.

- a. Provide a digital signature with digital certificate on electronically submitted certificates and certifications where indicated.
- b. Provide a notarized statement on original paper copy certificates and certifications where indicated.

B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

- 1. If information must be specially prepared for submittal because standard printed data are not suitable for use, submit as Shop Drawings, not as Product Data.
- 2. Mark each copy of each submittal to show which products and options are applicable.
- 3. Include the following information, as applicable
 - a. Manufacturer's written recommendations
 - b. Manufacturer's product specifications
 - c. Manufacturer's installation instructions
 - d. Standard color charts
 - e. Manufacturer's catalog cuts
 - f. Wiring diagrams showing factory-installed wiring.
 - g. Printed performance curves
 - h. Operational range diagrams.
 - i. Mill reports.
 - j. Standard product operating and maintenance manuals
 - k. Compliance with recognized trade association standards
 - l. Compliance with recognized testing agency standards.
 - m. Application of testing agency labels and seals
 - n. Notation of coordination requirements.
 - o. PDF electronic file

C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.

- 1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
 - a. Dimensions.
 - b. Identification of products.
 - c. Fabrication and installation drawings.
 - d. Roughing-in and setting diagrams.
 - e. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - f. Shopwork manufacturing instructions.
 - g. Templates and patterns.
 - h. Schedules.
 - i. Design calculations, with Professional Engineer's stamp as required.
 - j. Compliance with specified standards.
 - k. Notation of coordination requirements.

- 2. Submit Shop Drawings in the following format:

- a. PDF electronic file.
- D. Coordination Drawings: Comply with requirements in Division 01 Section "Project Management and Coordination." Submit in same format and quantity as Shop Drawings.
- E. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other elements and for a comparison of these characteristics between submittal and actual component as delivered and installed.
 - 1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package.
 - 2. Identification: Attach label on unexposed side of Samples that includes the following:
 - a. Generic description of Sample.
 - b. Product name and name of manufacturer.
 - c. Sample source.
 - d. Number and title of applicable Specification Section.
 - e. Specification paragraph number and generic name of each item.
 - 3. For projects where electronic submittals are required, provide corresponding electronic submittal of Sample transmittal, digital image file illustrating Sample characteristics, and identification information for record.
 - 4. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.
 - a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in undamaged condition at time of use.
 - b. Samples not incorporated into the Work, or otherwise designated as COTR's property, are the property of Contractor.
 - 5. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.
 - a. Number of Samples: Submit 2 of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. COTR will return submittal with options selected.
 - 6. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured, and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.
 - a. Number of Samples: Submit three sets of Samples. COTR will retain one Sample set; remainder will be returned to Contractor with submittal response. Contractor to retain one returned Sample set as a project record sample.
 - 1) Submit a single Sample where assembly details, workmanship, fabrication techniques, connections, operation, and other similar characteristics are to be demonstrated.

- 2) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.
- F. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
 2. Manufacturer and product name, and model number if applicable.
 3. Number and name of room or space.
 4. Location within room or space.
 5. Submit product schedule in the following format:
 - a. PDF electronic file.
- G. Professional Certification Submittal: Comply with requirements in Division 01 Section "Quality Requirements." Shop drawings, calculations, and other submittals that are required by the technical specifications to be prepared and/or reviewed by a registered, licensed design professional shall display the stamp/seal, registration/license number, and signature of the individual taking responsibility. Individuals must be registered/licensed in the state or jurisdiction in which the Project is located. Contractor's Construction Schedule: Comply with requirements in Division 01 Section "Construction Progress Documentation."
- H. Submittals Schedule: Comply with requirements in Division 01 Section "Construction Progress Documentation."
- I. Application for Payment: Comply with requirements in Division 01 Section "Payment Procedures."
- J. Schedule of Values: Comply with requirements in Division 01 Section "Payment Procedures."
- K. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, names, and addresses of architects and COTRs, and other specified information.
- L. Certificates:
1. Product Certificates: Prepare written statements on manufacturer's letterhead certifying that product complies with requirements
 2. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements. Submit record of Welding Procedure Specification (WPS) and Procedure Qualification Record (PQR) on AWS forms. Include names of firms and personnel certified.
2. Installer Certificates: Prepare written statements on manufacturer's letterhead certifying that Installer complies with requirements and, where required, is authorized for this specific Project
4. Manufacturer Certificates: Prepare written statements on manufacturer's letterhead certifying that manufacturer complies with requirements. Include evidence of manufacturing experience where required.
 5. Material Certificates: Prepare written statements on manufacturer's letterhead certifying That material complies with requirements.
- M. Test Reports:
1. Material Test Reports: Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements
 2. Preconstruction Test Reports: Prepare reports written by a qualified testing agency, on

testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements.

3. Compatibility Test Reports: Prepare reports written by a qualified testing agency, on Testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for primers and substrate preparation needed for adhesion.
 4. Field Test Reports: Prepare reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements
 5. Product Test Reports: Prepare written reports indicating current product produced by manufacturer complies with requirements. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests Performed by a qualified testing agency.
- N. Research/Evaluation Reports: Prepare written evidence, if required, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:
1. Name of evaluation organization.
 2. Date of evaluation
 3. Time period when report is in effect.
 4. Product and manufacturers' names.
 5. Description of product.
 6. Test procedures and results.
 7. Limitations of use.
- O. Maintenance Data: Prepare written and graphic instructions and procedures for operation and normal maintenance of products and equipment. Comply with requirements in Division 01 Section "Operation and Maintenance Data."
- P. Design Data: Prepare written and graphic information, including, but not limited to, performance and design criteria, list of applicable codes and regulations, and calculations. Include list of assumptions and other performance and design criteria and a summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Include page numbers.
- Q. Manufacturer's Instructions: Prepare written or published information that documents manufacturer's recommendations, guidelines, and procedures for installing or operating a product or equipment. Include name of product and name, address, and telephone number of manufacturers. Include the following, as applicable:
1. Preparation of substrates.
 2. Required substrate tolerances.
 3. Sequence of installation or erection.
 4. Required installation tolerances.
 5. Required adjustments.
 6. Recommendations for cleaning and protection.
- R. Manufacturer's Field Reports: Prepare written information documenting factory-authorized service representative's tests and inspections. Include the following, as applicable:
1. Name, address, and telephone number of factory-authorized service representative making report.
 2. Statement on condition of substrates and their acceptability for installation of product.

3. Statement that products at Project site comply with requirements.
 4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
 5. Results of operational and other tests and a statement of whether observed performance comply with requirements.
 6. Statement whether conditions, products, and installation will affect warranty.
 7. Other required items indicated in individual Specification Sections.
- S. Insurance Certificates and Bonds: Prepare written information indicating the current status of insurance or bonding coverage. Include name of entity covered by insurance or bond, limits of coverage, amounts of deductibles, if any, and the term of the coverage.
- T. Construction Photographs and Videotapes: Comply with requirements in Division 01 Section "Photographic Documentation."
- U. Material Safety Data Sheets: Submit information to COTR as required by technical specifications.

2.2 DELEGATED DESIGN SERVICES

- A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to COTR.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

- A. Review each submittal and check for compliance with the Construction Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to the COTR.
1. Assure that all submittals use the appropriate units of measure. All drawings and technical data shall be in metric units for projects designed in metric units.
 2. Transmit all required submittals for a technical specification section at the same time unless prior written waiver of this requirement has been provided by the COTR.
 3. Transmit submittals to the COTR in a logical and orderly sequence in accordance with the Submittal Schedule to prevent project delays or adversely impact work by the Smithsonian Institution, its consultants, or other Contractors.

- B. Approval Stamp: Stamp each submittal with a uniform, approval stamp. Include Project name and location, submittal number, Specification Section title and number, name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

3.2 COTR ACTION

- A. The COTR will not review submittals that do not bear Contractor's approval stamp and will return them without action.
- B. Submittals: The Architect/Engineer will review each submittal, make marks to indicate corrections or modifications required, and return it. The Architect/Engineer will stamp each submittal with an action stamp and will mark stamp appropriately to indicate action taken (and

recommended to the COTR). The COTR reviews the action recommended by the A/E and provides official action taken on the submittal to the Contractor on the Smithsonian Institution submittal stamp as follows:

1. Approved
 2. Approved as noted
 3. Revise and Resubmit
 4. Rejected
- C. Informational Submittals: The COTR and Architect/Engineer will review each submittal and will not return it or will reject and return it if it does not comply with requirements. The COTR will forward each submittal to appropriate party.
- D. Submittals not required by the Construction Documents may not be reviewed and may be discarded.
- E. Submittals not in the appropriate system of measurement will be rejected without review. Pre-printed literature may be annotated. Shop drawings prepared for this project must be in appropriate scale(s).
- F. Submittal approval by the COTR shall not relieve the Contractor of responsibility for submittal errors, omissions, or deviations from the Contract Documents. Approval of submittals does not constitute acceptance of substitutions, except as covered under subparagraph "Request for Substitutions," above.

3.3 SUBSEQUENT CONTRACTOR'S ACTION

- A. Correct and resubmit submittals, as necessary, according to response from the COTR.
- B. Commence Work on items requiring submittals only after all related submittals are reviewed and approved by the COTR. All work shall conform to Contract Documents and approved submittals.
- C. Retain copies of all approved submittals in their entirety for use in compiling Project Record Documents. See Division 01 Section "Project Record Documents."

END OF SECTION 013300

SECTION 01 3573 - DELEGATED DESIGN REQUIREMENTS AND PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes procedures for portions of Work under this Contract that include delegated design requirements and procedures.
- B. Related Requirements:
 - 1. Section 01 3100 "Project Management and Coordination" for project management and coordination with delegated design requirements.
 - 2. Section 01 3300 "Submittal Procedures" for quality control of submittal procedure and coordination with delegated design requirements.
 - 3. Section 01 4000 "Quality Requirements" for quality assurance requirements with delegated design requirements.

1.2 DEFINITIONS

- A. Delegated Design: A portion or component of the Work identified by the Contract Documents to be designed by the Contractor, or an entity assigned by the Contractor, to satisfy performance and design criteria specified in the Contract Documents for that portion or component.
- B. Registered Design Professional: Design professional, assigned by the Contractor, who is responsible for providing the delegated design work, and for certifying that the work is in compliance with the specified performance requirements and design criteria. Design professional shall be legally qualified to practice in jurisdiction where Project is located and shall be experienced in providing delegated design services of the kind indicated. Delegated design services are defined as those performed for installation of the system, assembly or product that are similar in material, design, and extent to those indicated for this Project.
- C. AHJ: Authority having jurisdiction.
- D. Technical Sections: Specification sections included in Divisions 02 through 35 of the Project Manual.

1.3 SUBMITTAL PROCEDURES

- A. Performance and Design Criteria: Where delegated design services are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
 - 1. If specific performance and design criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.
 - 2. Architect's and Engineer's review of delegated design submittal shall be for conformance with performance and design criteria only.
- B. Delegated-Design Services Submittal: Include Shop Drawings, Product Data, and other required submittals indicated in individual technical sections. Submit digitally signed PDF electronic file of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. In addition to other submittal requirements specified in other technical sections, at minimum, include the following in delegated design submittal:
 - a. Statement of design and performance criteria identified by the Contract Documents.
 - b. Assumptions.
 - c. Details, calculations, etc. related to the performance criteria.
 - d. Reactions to structure (where applicable).
 - e. Instructions for fabrication, assembly, installation, and interface with other trades.
 2. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.
- C. BIM File Incorporation: Incorporate delegated-design drawing and data files into Building Information Model established for Project.
1. Prepare delegated-design drawings in the following format: Same digital data software program, version, and operating system as the original Drawings.
- D. Submittal Procedures for Delegated Design Components:
1. Comply with requirements specified for other types of submittals included in this Section, including, but not limited to, form and procedures for delivering submittals.
 - a. Submit delegated design documents for approval prior to fabrication of components included in delegated design work.
 - b. Architect's review of delegated design submittals is for the limited purpose of checking for general conformance with information given and the design intent expressed in the Contract Documents. Architect will review submittals consistent with this limited purpose.
 - 1) Architect's review does not lessen nor shift burden or responsibility from Contractor to Architect or Owner.
 - 2) If during submittal review, Architect notes any deficiencies or errors, submittal will be returned with comments. Otherwise, there will be no responsive action by Architect.
 2. Delegated Design Submittal Schedule: Submit list of items identified in the Contract Documents that require delegated design. For each item, include the delegated design entity and the registered design professional.
 - a. If required, submit schedule to the authority having jurisdiction.
 3. Preliminary Submission: In order to avoid engineering and detailing of an unacceptable design, and if required by individual technical section, submit to Architect, preliminary documentation describing registered design professional's design prior to preparing engineering calculations and shop drawings.
 4. Delegated Design Submission: Submit final delegated design documents to Architect and AHJ if required for review, allowing not less than 10 days for review by Architect, and Architect's consultants and AHJ.
 - a. Comply with AHJ requirements.
 - b. Ensure registered design professional's signed seal is affixed to documents in accordance with jurisdictional requirements.
 - c. Make corrections noted by Architect and comply with AHJ requirements.

1.4 RESPONSIBILITIES

- A. General Contractor's Responsibilities:

1. Ensure drawings, calculations, specifications, and other documentation provided by registered design professional are complete and are sealed and signed by the registered design professional in accordance with requirements of AHJ. Architect and Owner shall be entitled to rely on the completeness and accuracy of the documentation provided by the registered design professional.
 2. Coordinate and assign complete responsibility for design, documentation, calculations, and submittal of delegated design components.
 3. Coordinate components requiring delegated design with adjacent or related systems whether designed by Architect or another entity. Ensure complete, operational systems that perform their intended are provided.
 4. When required to be reviewed by AHJ, submit delegated design documentation for in a timely manner that will not negatively impact Project's construction schedule.
 5. Performance requirements and design criteria are described in each technical section requiring delegated design. Conduct thorough review of other related portions of the Contract Documents to ensure inclusion of full scope of work in delegated design preparation and submittals.
 - a. Provide products and systems complying with specific performance and design criteria indicated.
 6. Comply with quality assurance requirements specified in individual technical sections containing delegated design requirements.
 7. Comply with accessibility guidelines, codes, policies, and standards required by the AHJ, applicable to the project, and as indicated.
- B. Registered Design Professional: Responsibilities include, but are not limited to, the following:
1. Sole responsibility to ensure delegated design accommodates all building movements, including, but not limited to deflection, rotation, creep, shrinkage, live loads, wind loads, and loads, interim and otherwise, resulting from means and methods.
 2. If applicable, prepare documentation required by AHJ.
 3. Prepare delegated design submittals that are sealed and signed by registered design professional.
- C. Architect's Responsibilities: Architect will review and mark submittals in accordance with procedures defined in Section 01 3300 "Submittal Procedures", using the action codes defined in that section.
- 1.5 SCHEDULING
- A. Schedule delegated design activities and submittals to occur in a timely manner that will not negatively impact Project's construction schedule.
1. Allow sufficient time for Architect's review of delegated design submittals.
 2. If Architect's approval of shop drawings relating to delegated design components is required prior to application for permit, schedule and sequence delegated design shop drawing review prior to permit submittal. Comply with requirements of Section 01 3300 "Submittal Procedures."
- B. Owner will not be responsible to pay for delays, additional products, additional hours of work, including overtime, restocking or rework required due to failure by Contractor to coordinate delegated design work with work of other trades.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

END OF SECTION

FOR REFERENCE ONLY

SECTION 014000 - QUALITY REQUIREMENTS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for quality assurance and quality control.
- B. All Tests and inspections required under the project's contract documents, even ones explicitly assigned to Owner are the Contractor's responsibility to provide with an independent approved subcontractor.
 - 1. Specific quality-control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit Contractor's quality-control procedures that facilitate compliance with the Construction Document requirements.
 - 3. Requirements for Contractor to provide quality-control services required by the COTR or authorities having jurisdiction are not limited by provisions of this Section.
 - 4. Specific test and inspection requirements are not specified in this Section.
- C. Related Sections include the following:
 - 1. Division 01 Section 013200 "Construction Progress Documentation" for developing a schedule of required tests and inspections.
 - 2. Division 01 Section 013300 "Submittal Procedures."
 - 3. Testing and Inspection Services identified in other specification sections.
 - 4. Division 01 Section 017300 "Execution" for repair and restoration of construction disturbed by testing and inspecting activities and for the installation or performance of other components of the Work.

1.3 DEFINITIONS

- A. Quality Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the work and completed construction comply with requirements. Services do not include contract enforcement activities performed by the COTR.
- C. Mockups: Full-size physical assemblies that are constructed on-site. Mockups are constructed to verify selections made under Sample submittals; to demonstrate aesthetic effects and, where indicated, qualities of materials and execution; to review coordination, testing, or operation; to show interface between dissimilar materials; and to demonstrate compliance with specified installation tolerances. Mockups are not Samples. Unless otherwise indicated, approved mockups establish the standard by which the Work will be judged.
 - 1. Laboratory Mockups: Full-size physical assemblies constructed at testing facility

- to verify performance characteristics.
- 2. Integrated Exterior Mockups: Mockups of the exterior envelope erected separately from the building but on Project site, consisting of multiple products, assemblies, and subassemblies.
- 3. Room Mockups: Mockups of typical interior spaces complete with wall, floor, and ceiling finishes, doors, windows, millwork, casework, specialties, furnishings and equipment, and lighting.
- D. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria.
- E. Product Testing: Tests and inspections that are performed by an NRTL, an NVLAP, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.
- F. Source Quality-Control Testing: Tests and inspections that are performed at the source, e.g., plant, mill, factory, or shop.
- G. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- H. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- I. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
 - 1. Use of trade-specific terminology in referring to a trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).
- J. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of 10 previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

1.4 PROFESSIONAL CERTIFICATIONS

- A. Construction Document Performance and Design Criteria: Where professional design services or certifications (e.g., design calculations and/or shop drawings signed, stamped, and sealed by a professional, licensed engineer) by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.
 - 1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to the COTR.
 - 2. Shop drawings, calculations, and other submittals that are required by the technical specifications to be prepared and/or reviewed by a registered, licensed design professional shall display the stamp/seal, registration/license number, name, and signature of the individual holding responsibility. The individual must be registered/licensed in the state or jurisdiction in which the Project is located.

1.5 REGULATORY REQUIREMENTS

- A. Copies of Regulations: Obtain or provide access to copies of governing regulations upon request. Retain copies of regulations, as reasonable, at Project site to be available for reference.

1.6 SUBMITTALS

- A. Qualifications: Submit evidence of fabricator, installer, manufacturer, or other representative experience as described below and required in the individual Specification sections.
- B. Professional Certification Submittal: In addition to Construction Documents, Shop Drawings, Product Data, and other required submittals, submit a statement, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional, indicating that the products and systems are in compliance with performance and design criteria indicated. Include list of codes, loads, and other factors used in performing these services.
- C. Permits, Licenses, and Certificates: For Smithsonian Institution's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.7 QUALITY ASSURANCE

- A. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- B. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- C. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance. If required by the individual specification section, installers must be acceptable to and/or authorized by product/system manufacturer.
- D. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance.
- E. Specialists: Certain sections of the Specifications require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
 - 1. Requirement for specialists shall not supersede building codes and similar regulations governing the Work, nor interfere with local trade-union jurisdictional settlements and similar conventions.

1.8 QUALITY CONTROL

- A. Smithsonian Institution Responsibilities: Inspection of the Work may be done on a daily basis by the COTR. The SI will have appropriate personnel available to witness Owner System Performance Verification (OSPV) tests.
- B. Contractor Responsibilities: Unless otherwise indicated, provide quality-control services specified and required by authorities having jurisdiction. Ensure that the Work complies with the quality and workmanship requirements in the technical specifications. Ensure that representatives from all

applicable subcontractors and manufacturers are available during multiple systems commissioning and Owner System Performance Verification tests.

- C. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting. Coordinate construction activities and planning with existing conditions.
- D. Contactor shall notify COTR at least 24 hours prior to any concealment activities to give SI the opportunity to schedule any pre-concealment inspections or documentation desired.

1.9 Paragraph below may resolve issues that sometimes arise when using referenced standards due to conflicting requirements in the Contract Documents. Coordinate with Conditions of the Contract. Revise to suit Project, office policy, and Owner's requirements.

- A. Referenced Standards: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to COTR for a decision before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements.

1.10 ACTION SUBMITTALS

- A. Shop Drawings: For mockups, provide plans, sections, and elevations, indicating materials and size of mockup construction.
 - 1. Indicate manufacturer and model number of individual components.
 - 2. Provide axonometric drawings for conditions difficult to illustrate in two dimensions.

1.11 INFORMATIONAL SUBMITTALS

- A. Contractor's Quality-Control Plan: For quality-assurance and quality-control activities and responsibilities.
- B. Qualification Data: For Contractor's quality-control personnel.
- C. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility sent to authorities having jurisdiction before starting work on the following systems:
 - 1. Seismic-force-resisting system, designated seismic system, or component listed in the designated seismic system quality-assurance plan prepared by Architect.
 - 2. Main wind-force-resisting system or a wind-resisting component listed in the wind-force-resisting system quality-assurance plan prepared by Architect.
- D. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

A. Schedule of Tests and Inspections: Prepare in tabular form and include the following:

1. Specification Section number and title.
2. Entity responsible for performing tests and inspections.
3. Description of tests and inspection.
4. Identification of applicable standards.
5. Identification of test and inspection methods.
6. Number of tests and inspections required.
7. Time schedule or time span for tests and inspections.
8. Requirements for obtaining samples.
9. Unique characteristics of each quality-control service.

1.12 CONTRACTOR'S QUALITY-CONTROL PLAN

- A. Quality-Control Plan, General: Submit quality-control plan within **10** days of **Notice to Proceed**, and not less than **five** days prior to preconstruction conference. Submit in a format that is acceptable to the Architect. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-assurance and quality-control responsibilities. Coordinate with Contractor's construction schedule.
- B. Quality-Control Personnel Qualifications: Engage qualified trained and experienced in managing and executing quality-assurance and quality-control procedures similar in nature and extent to those required for Project.
- C. Submittal Procedure: Describe procedures for ensuring compliance with requirements through review and management of submittal process. Indicate qualifications of personnel responsible for submittal review.
- D. Testing and Inspection: In quality-control plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:
1. Contractor-performed tests and inspections including subcontractor-performed tests and inspections. Include required tests and inspections and Contractor-elected tests and inspections.
 2. Special inspections required by authorities having jurisdiction and indicated on the "Statement of Special Inspections."
- E. Continuous Inspection of Workmanship: Describe process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and specified inspection. Indicate types of corrective actions to be required to bring work into compliance with standards of workmanship established by Contract requirements and approved mockups.
- F. Monitoring and Documentation: Maintain testing and inspection reports including a log of approved and rejected results. Include work COTR. Indicate corrective actions taken to bring nonconforming work into compliance with requirements. Comply with requirements of authorities having jurisdiction.

1.13 REPORTS AND DOCUMENTS

- A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:

1. Date of issue.
 2. Project title and number.
 3. Name, address, and telephone number of testing agency.
 4. Dates and locations of samples and tests or inspections.
 5. Names of individuals making tests and inspections.
 6. Description of the Work and test and inspection method.
 7. Identification of product and Specification Section.
 8. Complete test or inspection data.
 9. Test and inspection results and an interpretation of test results.
 10. Record of temperature and weather conditions at time of sample taking and testing and inspecting.
 11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
 12. Name and signature of laboratory inspector.
 13. Recommendations on retesting and re-inspecting.
- B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:
1. Name, address, and telephone number of technical representative making report.
 2. Statement on condition of substrates and their acceptability for installation of product.
 3. Statement that products at Project site comply with requirements.
 4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
 5. Results of operational and other tests and a statement of whether observed performance comply with requirements.
 6. Statement weather conditions, products, and installation will affect warranty.
 7. Other required items indicated in individual Specification Sections.
- C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:
1. Name, address, and telephone number of factory-authorized service representative making report.
 2. Statement that equipment complies with requirements.
 3. Results of operational and other tests and a statement of whether observed performance comply with requirements.
 4. Statement weather conditions, products, and installation will affect warranty.
 5. Other required items indicated in individual Specification Sections.
- D. Permits, Licenses, and Certificates: For Owner's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.14 QUALITY ASSURANCE

- A. General: Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful service performance, as well as sufficient production capacity to produce required units.

- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or product that are similar in material, design, and extent to those indicated for this Project.
- F. Specialists: Certain Specification Sections require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
 - 1. Requirements of authorities having jurisdiction shall supersede requirements for specialists.
- G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to **ASTM E 329**;
 and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, which is acceptable to authorities.
 - 1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 - 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- H. Manufacturer's Technical Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- I. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- J. Preconstruction Testing: Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:
 - 1. Contractor responsibilities include the following:
 - a. Provide test specimens representative of proposed products and construction.
 - b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
 - c. Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
 - d. Build site-assembled test assemblies and mockups using installers who will

- perform same tasks for Project.
 - e. Build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
 - f. When testing is complete, remove test specimens, assemblies, do not reuse products on Project.
 - 2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to COTR. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.
 - K. Mockups: Before installing portions of the work requiring mockups, build mockups for each form of construction and finish required to comply with the following requirements, using materials indicated for the completed work:
 - 1. Build mockups in location and of size indicated or, if not indicated, as directed by COTR.
 - 2. Notify COTR **seven** days in advance of dates and times when mockups will be constructed.
 - 3. Employ supervisory personnel who will oversee mockup construction. Employ workers that will be employed during the construction at Project.
 - 4. Demonstrate the proposed range of aesthetic effects and workmanship.
 - 5. Obtain COTR approval of mockups before starting work, fabrication, or construction.
 - a. Allow **seven** days for initial review and each re-review of each mockup.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed unless otherwise indicated.
 - L. Integrated Exterior Mockups: Construct integrated exterior mockup **according to approved Shop Drawings**. Coordinate installation of exterior envelope materials and products for which mockups are required in individual Specification Sections, along with supporting materials.
- 1.15 QUALITY CONTROL
- A. Contractor Responsibilities: All Tests and inspections, even ones explicitly assigned to Owner/COTR are the Contractor's responsibility for coordination and compensation within the contract's award amount. Perform additional quality-control activities required to verify that the Work complies with requirements, whether specified or not.
 - 1. Provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.
 - 2. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality-control services.
 - 3. Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
 - 4. All Testing and inspecting requested by Contractor and are required by the Contract Documents are solely the Contractor's responsibility.
 - 5. Submit additional copies of each written report directly to authorities having jurisdiction.
 - B. Manufacturer's Field Services: Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Section 013300 "Submittal Procedures."
 - C. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the work. Manufacturer's technical representative's services

include participation in pre-installation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.

- D. Retesting/Re-inspecting: Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and re-inspecting, for construction that replaced Work that failed to comply with the Contract Documents.
- E. Testing Agency Responsibilities: Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
 - 1. Notify COTR and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
 - 2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
 - 3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
 - 4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
 - 5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
 - 6. Do not perform any duties of Contractor.
- F. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and - control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
 - 1. Schedule times for tests, inspections, obtaining samples, and similar activities.
- G. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a **component of Contractor's quality-control plan**. Coordinate and submit concurrently with Contractor's construction schedule. Update as the Work progresses.
 - 1. Distribution: Distribute schedule to COTR testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

1.16 SPECIAL TESTS AND INSPECTIONS

- A. Special Tests and Inspections: At the COTR's request a qualified **testing agency** to conduct special tests and inspections.
- B. Special Tests and Inspections: Conducted by a qualified **testing agency** as required and as follows:
 - 1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviews the completeness and adequacy of those procedures to perform the Work.
 - 2. Notifying COTR and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
 - 3. Submitting a certified written report of each test, inspection, and similar quality-control service to COTR with copy to Contractor and to authorities having jurisdiction.
 - 4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
 - 5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
 - 6. Retesting and re-inspecting corrected work.
 - 7. Clearly indicate on all report submissions COMPLIANT or NON-

COMPLIANT. PART 2 - PRODUCTS (Not Used)

PART 3 – EXECUTION

3.1 TEST AND INSPECTION LOG

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
 - 1. Date test or inspection was conducted.
 - 2. Description of the Work tested or inspected.
 - 3. Date test or inspection results were transmitted to Architect.
 - 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for **COTR**, reference during normal working hours.

3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
 - 1. Provide materials and comply with installation requirements specified in other Specification Sections or match existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 017300 "Execution."
- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

3.3 NON-CONFORMING WORK

- A. Remove portions of the Work that fail to conform to quality-control requirements of the Contract Documents.
- B. Replace defective portions of the Work as directed by the COTR. No adjustment will be made to Contract Sum nor Contract Time.

END OF SECTION 014000

SECTION 01 4200 - REFERENCES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- A. The Contract Documents in their entirety, including the Drawings, Specifications/Project Manual, Construction Contract Clauses, and any other documents issued as part of the Contract, apply to this Section.

1.2 DEFINITIONS

- A. General: Basic Contract definitions are included in the Conditions of the Contract.
- B. "Approved": The term "approved," when used in conjunction with COTR's action on Contractor's submittals, applications, and requests, is limited to COTR's duties and responsibilities as stated in the Conditions of the Contract. When using terms such as those in "Approved" and "Directed" paragraphs below, do not extend Architect's responsibility into Contractor's area of means, methods, and techniques of construction. See Evaluations.
- B. "Directed": Terms such as "directed," "requested," "authorized," "selected," "approved," "required," and "permitted" mean directed by COTR, requested by COTR, and similar phrases.
- D. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."
- E. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.
- F. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- G. "Install": Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.
- H. "Provide": Furnish and install, complete and ready for the intended use.
- I. "Project Site": Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.
- J. "Installer": An installer is Contractor or another entity engaged by Contractor, as an employee, subcontractor, or contractor of lower tier, to perform a particular construction operation, including installation, erection, application, and similar operations.
- K. The term "experienced," when used with the term "installer," means having successfully completed a minimum of **five** previous projects similar in size and scope to this Project; being familiar with the special requirements indicated; and having complied with requirements of authorities having jurisdiction.
 - 1. Using a term such as "carpentry" does not imply that certain construction activities must be

performed by accredited or unionized individuals of a corresponding generic name, such as "carpenter." It also does not imply that requirements specified apply exclusively to trades people of the corresponding generic name.

1.3 INDUSTRY STANDARDS

- A. SI Codes, Standards and Guidelines, current edition, shall cover the production of Construction Documents.
- B. Publication Dates: Comply with codes and standards in effect as of the date of the Contract Documents, unless otherwise indicated.
- C. Conflicting Requirements: Where compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to the COTR for a decision before proceeding.
 - 1. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of the requirements. Refer uncertainties to the COTR for a decision before proceeding.
- D. Copies of Codes and Standards: Each entity engaged in construction on Project must be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.
 - 1. Where copies of standards are needed to perform the required design or construction activity, obtain copies directly from the publication source and make them available on request.

1.4 ABBREVIATIONS AND ACRONYMS

- A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities indicated in Gale's "Encyclopedia of Associations: National Organizations of the U.S." or in Columbia Books' "National Trade & Professional Associations of the United States."
- B. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.
- C. Abbreviations and Names: Abbreviations and acronyms are frequently used in the Specifications and other Contract Documents to represent the name of a trade association, standards- developing organization, authorities having jurisdiction, or other entity in the context of referencing a standard or publication. Where abbreviations and acronyms are used in the Specifications or other Contract Documents, they mean the recognized name of these entities.

Refer to Gale Research's "Encyclopedia of Associations" or Columbia Books' "National Trade & Professional Associations of the U.S.," which are available in most libraries.

- 1. AABC - Associated Air Balance Council; www.aabc.com.
- 2. AAMA - American Architectural Manufacturers Association; www.aamanet.org.
- 3. AAPFCO - Association of American Plant Food Control Officials; www.aapfco.org.

4. AASHTO - American Association of State Highway and Transportation Officials; www.transportation.org.
5. AATCC - American Association of Textile Chemists and Colorists; www.aatcc.org.
6. ABMA - American Bearing Manufacturers Association; www.americanbearings.org.
7. ACI - American Concrete Institute; (Formerly: ACI International); www.concrete.org.
8. ACPA - American Concrete Pipe Association; www.concrete-pipe.org.
9. AEIC - Association of Edison Illuminating Companies, Inc. (The); www.aeic.org.
10. AF&PA - American Forest & Paper Association; www.afandpa.org.
11. AGA - American Gas Association; www.aga.org.
12. AHAM - Association of Home Appliance Manufacturers; www.aham.org.
13. AHRI - Air-Conditioning, Heating, and Refrigeration Institute (The); www.ahrinet.org.
14. AI - Asphalt Institute; www.asphaltinstitute.org.
15. AIA - American Institute of Architects (The); www.aia.org.
16. AISC - American Institute of Steel Construction; www.aisc.org.
17. AISI - American Iron and Steel Institute; www.steel.org.
18. AITC - American Institute of Timber Construction; www.aitc-glulam.org.
19. AMCA - Air Movement and Control Association International, Inc.; www.amca.org.
20. ANSI - American National Standards Institute; www.ansi.org.
21. AOSA - Association of Official Seed Analysts, Inc.; www.aosaseed.com.
22. APA - APA - The Engineered Wood Association; www.apawood.org.
23. APA - Architectural Precast Association; www.archprecast.org.
24. API - American Petroleum Institute; www.api.org.
25. ARI - Air-Conditioning & Refrigeration Institute; (See AHRI).
26. ARI - American Refrigeration Institute; (See AHRI).
27. ARMA - Asphalt Roofing Manufacturers Association; www.asphaltroofing.org.
28. ASCE - American Society of Civil Engineers; www.asce.org.
29. ASCE/SEI - American Society of Civil Engineers/Structural Engineering Institute; (See ASCE).
30. ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers; www.ashrae.org.
31. ASME - ASME International; (American Society of Mechanical Engineers); www.asme.org.
32. ASSE - American Society of Safety Engineers (The); www.asse.org.
33. ASSE - American Society of Sanitary Engineering; www.asse-plumbing.org.
34. ASTM - ASTM International; (American Society for Testing and Materials International); www.astm.org.
35. ATIS - Alliance for Telecommunications Industry Solutions; www.atis.org.
36. AWEA - American Wind Energy Association; www.awea.org.
37. AWI - Architectural Woodwork Institute; www.awinet.org.
38. AWMAC - Architectural Woodwork Manufacturers Association of Canada; www.awmac.com.
39. AWP - American Wood Protection Association; (Formerly: American Wood-Preservers' Association); www.awpa.com.
40. AWS - American Welding Society; www.aws.org.
41. AWWA - American Water Works Association; www.awwa.org.
42. BHMA - Builders Hardware Manufacturers Association; www.buildershardware.com.
43. BIA - Brick Industry Association (The); www.gobrick.com.
44. BICSI - BICSI, Inc.; www.bicsi.org.
45. BIFMA - BIFMA International; (Business and Institutional Furniture Manufacturer's Association); www.bifma.com.
46. BISSC - Baking Industry Sanitation Standards Committee; www.bissc.org.
47. BOCA - BOCA; (Building Officials and Code Administrators International Inc.); (See ICC).
48. BWF - Badminton World Federation; (Formerly: International Badminton Federation); www.bwfbadminton.org.
49. CDA - Copper Development Association; www.copper.org.
50. CEA - Canadian Electricity Association; www.electricity.ca.

51. CEA - Consumer Electronics Association; www.ce.org.
52. CFFA - Chemical Fabrics & Film Association, Inc.; www.chemicalfabricsandfilm.com.
53. CFSEI - Cold-Formed Steel Engineers Institute; www.cfsei.org.
54. CGA - Compressed Gas Association; www.cganet.com.
55. CIMA - Cellulose Insulation Manufacturers Association; www.cellulose.org.
56. CISCA - Ceilings & Interior Systems Construction Association; www.cisca.org.
57. CISPI - Cast Iron Soil Pipe Institute; www.cispi.org.
58. CLFMI - Chain Link Fence Manufacturers Institute; www.chainlinkinfo.org.
59. CPA - Composite Panel Association; www.pbmdf.com.
60. CRI - Carpet and Rug Institute (The); www.carpet-rug.org.
61. CRRC - Cool Roof Rating Council; www.coolroofs.org.
62. CRSI - Concrete Reinforcing Steel Institute; www.crsi.org.
63. CSA - Canadian Standards Association; www.csa.ca.
64. CSA - CSA International; (Formerly: IAS - International Approval Services); www.csa-international.org.
65. CSI - Construction Specifications Institute (The); www.csinet.org.
66. CSSB - Cedar Shake & Shingle Bureau; www.cedarbureau.org.
67. CTI - Cooling Technology Institute; (Formerly: Cooling Tower Institute); www.cti.org.
68. CWC - Composite Wood Council; (See CPA).
69. DASMA - Door and Access Systems Manufacturers Association; www.dasma.com.
70. DHI - Door and Hardware Institute; www.dhi.org.
71. ECA - Electronic Components Association; www.ec-central.org.
72. ECAMA - Electronic Components Assemblies & Materials Association; (See ECA).
73. EIA - Electronic Industries Alliance; (See TIA).
74. EIMA - EIFS Industry Members Association; www.eima.com.
75. EJMA - Expansion Joint Manufacturers Association, Inc.; www.ejma.org.
76. ESD - ESD Association; (Electrostatic Discharge Association); www.esda.org.
77. ESTA - Entertainment Services and Technology Association; (See PLASA).
78. EVO - Efficiency Valuation Organization; www.evo-world.org.
79. FIBA - Federation Internationale de Basketball; (The International Basketball Federation); www.fiba.com.
80. FIVB - Federation Internationale de Volleyball; (The International Volleyball Federation); www.fivb.org.
81. FM Approvals - FM Approvals LLC; www.fmglobal.com.
82. FM Global - FM Global; (Formerly: FMG - FM Global); www.fmglobal.com.
83. FRSA - Florida Roofing, Sheet Metal & Air Conditioning Contractors Association, Inc.; www.floridarooft.com.
84. FSA - Fluid Sealing Association; www.fluidsealing.com.
85. FSC - Forest Stewardship Council U.S.; www.fscus.org.
86. GA - Gypsum Association; www.gypsum.org.
87. GANA - Glass Association of North America; www.glasswebsite.com.
88. GS - Green Seal; www.greenseal.org.
89. HI - Hydraulic Institute; www.pumps.org.
90. HI/GAMA - Hydronics Institute/Gas Appliance Manufacturers Association; (See AHRI).
91. HMMA - Hollow Metal Manufacturers Association; (See NAAMM).
92. HPVA - Hardwood Plywood & Veneer Association; www.hpva.org.
93. HPW - H. P. White Laboratory, Inc.; www.hpwhite.com.
94. IAPSC - International Association of Professional Security Consultants; www.iapsc.org.
95. IAS - International Approval Services; (See CSA).
96. ICBO - International Conference of Building Officials; (See ICC).
97. ICC - International Code Council; www.iccsafe.org.
98. ICEA - Insulated Cable Engineers Association, Inc.; www.icea.net.
99. ICPA - International Cast Polymer Alliance; www.icpa-hq.org.
100. ICRI - International Concrete Repair Institute, Inc.; www.icri.org.
101. IEC - International Electrotechnical Commission; www.iec.ch.
102. IEEE - Institute of Electrical and Electronics Engineers, Inc. (The); www.ieee.org.

103. IES - Illuminating Engineering Society; (Formerly: Illuminating Engineering Society of North America); www.ies.org.
104. IESNA - Illuminating Engineering Society of North America; (See IES).
105. IEST - Institute of Environmental Sciences and Technology; www.iest.org.
106. IGMA - Insulating Glass Manufacturers Alliance; www.igmaonline.org.
107. IGSHPA - International Ground Source Heat Pump Association; www.igshpa.okstate.edu.
108. ILI - Indiana Limestone Institute of America, Inc.; www.iliai.com.
109. Intertek - Intertek Group; (Formerly: ETL SEMCO; Intertek Testing Service NA); www.intertek.com.
110. ISA - International Society of Automation (The); (Formerly: Instrumentation, Systems, and Automation Society); www.isa.org.
111. ISAS - Instrumentation, Systems, and Automation Society (The); (See ISA).
112. ISFA - International Surface Fabricators Association; (Formerly: International Solid Surface Fabricators Association); www.isfanow.org.
113. ISO - International Organization for Standardization; www.iso.org.
114. ISSFA - International Solid Surface Fabricators Association; (See ISFA).
115. ITU - International Telecommunication Union; www.itu.int/home.
116. KCMA - Kitchen Cabinet Manufacturers Association; www.kcma.org.
117. LMA - Laminating Materials Association; (See CPA).
118. LPI - Lightning Protection Institute; www.lightning.org.
119. MBMA - Metal Building Manufacturers Association; www.mbma.com.
120. MCA - Metal Construction Association; www.metalconstruction.org.
121. MFMA - Maple Flooring Manufacturers Association, Inc.; www.maplefloor.org.
122. MFMA - Metal Framing Manufacturers Association, Inc.; www.metalframingmfg.org.
123. MHIA - Material Handling Industry of America; www.mhia.org.
124. MIA - Marble Institute of America; www.marble-institute.com.
125. MMPA - Moulding & Millwork Producers Association; (Formerly: Wood Moulding & Millwork Producers Association); www.wmmpa.com.
126. MPI - Master Painters Institute; www.paintinfo.com.
127. MSS - Manufacturers Standardization Society of The Valve and Fittings Industry Inc.; www.mss-hq.org.
128. NAAMM - National Association of Architectural Metal Manufacturers; www.naamm.org.
129. NACE - NACE International; (National Association of Corrosion Engineers International); www.nace.org.
130. NADCA - National Air Duct Cleaners Association; www.nadca.com.
131. NAIMA - North American Insulation Manufacturers Association; www.naima.org.
132. NBGQA - National Building Granite Quarries Association, Inc.; www.nbgqa.com.
133. NCAA - National Collegiate Athletic Association (The); www.ncaa.org.
134. NCMA - National Concrete Masonry Association; www.ncma.org.
135. NEBB - National Environmental Balancing Bureau; www.nebb.org.
136. NECA - National Electrical Contractors Association; www.necanet.org.
137. NELMA - Northeastern Lumber Manufacturers Association; www.nelma.org.
138. NEMA - National Electrical Manufacturers Association; www.nema.org.
139. NETA - InterNational Electrical Testing Association; www.netaworld.org.
140. NFHS - National Federation of State High School Associations; www.nfhs.org.
141. NFPA - NFPA; (National Fire Protection Association); www.nfpa.org.
142. NFPA - NFPA International; (See NFPA).
143. NFRC - National Fenestration Rating Council; www.nfrc.org.
144. NHLA - National Hardwood Lumber Association; www.nhla.com.
145. NLGA - National Lumber Grades Authority; www.nlga.org.
146. NOFMA - National Oak Flooring Manufacturers Association; (See NWFA).
147. NOMMA - National Ornamental & Miscellaneous Metals Association; www.nomma.org.
148. NRCA - National Roofing Contractors Association; www.nrca.net.
149. NRMCA - National Ready Mixed Concrete Association; www.nrmca.org.
150. NSF - NSF International; (National Sanitation Foundation International); www.nsf.org.
151. NSPE - National Society of Professional Engineers; www.nspe.org.

152. NSSGA - National Stone, Sand & Gravel Association; www.nssga.org.
153. NTMA - National Terrazzo & Mosaic Association, Inc. (The); www.ntma.com.
154. NWFA - National Wood Flooring Association; www.nwfa.org.
155. PCI - Precast/Prestressed Concrete Institute; www.pci.org.
156. PDI - Plumbing & Drainage Institute; www.pdionline.org.
157. PLASA - PLASA; (Formerly: ESTA - Entertainment Services and Technology Association); www.plasa.org.
158. RCSC - Research Council on Structural Connections; www.boltcouncil.org.
159. RFCI - Resilient Floor Covering Institute; www.rfci.com.
160. RIS - Redwood Inspection Service; www.redwoodinspection.com.
161. SAE - SAE International; (Society of Automotive Engineers); www.sae.org.
162. SCTE - Society of Cable Telecommunications Engineers; www.scte.org.
163. SDI - Steel Deck Institute; www.sdi.org.
164. SDI - Steel Door Institute; www.steeldoor.org.
165. SEFA - Scientific Equipment and Furniture Association; www.sefalabs.com.
166. SEI/ASCE - Structural Engineering Institute/American Society of Civil Engineers; (See ASCE).
167. SIA - Security Industry Association; www.siaonline.org.
168. SJI - Steel Joist Institute; www.steeljoist.org.
169. SMA - Screen Manufacturers Association; www.smainfo.org.
170. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association; www.smacna.org.
171. SMPTE - Society of Motion Picture and Television Engineers; www.smpte.org.
172. SPFA - Spray Polyurethane Foam Alliance; www.sprayfoam.org.
173. SPIB - Southern Pine Inspection Bureau; www.spib.org.
174. SPRI - Single Ply Roofing Industry; www.spri.org.
175. SRCC - Solar Rating and Certification Corporation; www.solar-rating.org.
176. SSINA - Specialty Steel Industry of North America; www.ssina.com.
177. SSPC - SSPC: The Society for Protective Coatings; www.sspc.org.
178. STI - Steel Tank Institute; www.steeltank.com.
179. SWI - Steel Window Institute; www.steelwindows.com.
180. SWPA - Submersible Wastewater Pump Association; www.swpa.org.
181. TCA - Tilt-Up Concrete Association; www.tilt-up.org.
182. TCNA - Tile Council of North America, Inc.; (Formerly: Tile Council of America); www.tileusa.com.
183. TEMA - Tubular Exchanger Manufacturers Association, Inc.; www.tema.org.
184. TIA - Telecommunications Industry Association; (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance); www.tiaonline.org.
185. TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance; (See TIA).
186. TMS - The Masonry Society; www.masonrysociety.org.
187. TPI - Truss Plate Institute; www.tpinst.org.
188. TPI - Turfgrass Producers International; www.turfgrasssod.org.
189. TRI - Tile Roofing Institute; www.tilerroofing.org.
190. UBC - Uniform Building Code; (See ICC).
191. UL - Underwriters Laboratories Inc.; www.ul.com.
192. UNI - Uni-Bell PVC Pipe Association; www.uni-bell.org.
193. USAV - USA Volleyball; www.usavolleyball.org.
194. USGBC - U.S. Green Building Council; www.usgbc.org.
195. USITT - United States Institute for Theatre Technology, Inc.; www.usitt.org.
196. WASTEC - Waste Equipment Technology Association; www.wastec.org.
197. WCLIB - West Coast Lumber Inspection Bureau; www.wclib.org.
198. WCMA - Window Covering Manufacturers Association; www.wcmanet.org.
199. WDMA - Window & Door Manufacturers Association; www.wdma.com.
200. WI - Woodwork Institute; (Formerly: WIC - Woodwork Institute of

California); www.wicnet.org.

201. WMMPA - Wood Moulding & Millwork Producers Association; (See MMPA).

202. WSRCA - Western States Roofing Contractors Association; www.wsra.com.

203. WPA - Western Wood Products Association; www.wvpa.org.

D. Code Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is believed to be accurate as of the date of the Contract Documents.

1. DIN - Deutsches Institut für Normung e.V.; www.din.de.

2. IAPMO - International Association of Plumbing and Mechanical Officials; www.iapmo.org.

3. ICC - International Code Council; www.iccsafe.org.

4. ICC-ES - ICC Evaluation Service, LLC; www.icc-es.org.

E. Federal Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Information is subject to change and is up to date as of the date of the Contract Documents.

1. COE - Army Corps of Engineers; www.usace.army.mil.

2. CPSC - Consumer Product Safety Commission; www.cpsc.gov.

3. DOC - Department of Commerce; National Institute of Standards and Technology; www.nist.gov.

4. DOD - Department of Defense; <http://dodssp.daps.dla.mil>.

5. DOE - Department of Energy; www.energy.gov.

6. EPA - Environmental Protection Agency; www.epa.gov.

7. FAA - Federal Aviation Administration; www.faa.gov.

8. FG - Federal Government Publications; www.gpo.gov.

9. GSA - General Services Administration; www.gsa.gov.

10. HUD - Department of Housing and Urban Development; www.hud.gov.

11. LBL - Lawrence Berkeley National Laboratory; Environmental Energy Technologies Division; <http://eetd.lbl.gov>.

12. OSHA - Occupational Safety & Health Administration; www.osha.gov.

13. SD - Department of State; www.state.gov.

14. TRB - Transportation Research Board; National Cooperative Highway Research Program; www.trb.org.

15. USDA - Department of Agriculture; Agriculture Research Service; U.S. Salinity Laboratory; www.ars.usda.gov.

16. USDA - Department of Agriculture; Rural Utilities Service; www.usda.gov.

17. USDOJ - Department of Justice; Office of Justice Programs; National Institute of Justice; www.ojp.usdoj.gov.

18. USP - U.S. Pharmacopeia; www.usp.org.

19. USPS - United States Postal Service; www.usps.com.

F. Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the standards and regulations in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.

1. CFR - Code of Federal Regulations; Available from Government Printing Office; www.gpo.gov/fdsys.

2. DOD - Department of Defense; Military Specifications and Standards; Available from Department of Defense Single Stock Point; <http://dodssp.daps.dla.mil>.

3. DSCC - Defense Supply Center Columbus; (See FS).

4. FED-STD - Federal Standard; (See FS).

5. FS - Federal Specification; Available from Department of Defense Single

Stock Point; <http://dodssp.daps.dla.mil>.

- a. Available from Defense Standardization Program; www.dsp.dla.mil.
- b. Available from General Services Administration; www.gsa.gov.
- c. Available from National Institute of Building Sciences/Whole Building Design Guide; www.wbdg.org/ccb.

6. MILSPEC - Military Specification and Standards; (See DOD).
7. USAB - United States Access Board; www.access-board.gov.
8. USATBCB - U.S. Architectural & Transportation Barriers Compliance Board; (See USAB).

G. State Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.

1. CBHF - State of California; Department of Consumer Affairs; Bureau of Electronic Appliance and Repair, Home Furnishings and Thermal Insulation; www.bearhfti.ca.gov.
2. CCR - California Code of Regulations; Office of Administrative Law; California Title 24 Energy Code; www.calregs.com.
3. CDHS - California Department of Health Services; (See CDPH).
4. CDPH - California Department of Public Health; Indoor Air Quality Program; www.cal-iaq.org.
5. CPUC - California Public Utilities Commission; www.cpuc.ca.gov.
6. SCAQMD - South Coast Air Quality Management District; www.aqmd.gov.
7. TFS - Texas Forest Service; Forest Resource Development and Sustainable Forestry; <http://txforestservation.tamu.edu>

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 014200

SECTION 01 5000 - TEMPORARY FACILITIES AND CONTROLS**PART 1 – GENERAL****1.1 RELATED DOCUMENTS**

- A. The Contract Documents in their entirety, including the Drawings, Specifications, Construction Contract Clauses, and any other documents issued as part of the Contract, apply to this Section.

1.2 SUMMARY

- A. This Section includes requirements for temporary facilities and controls, including temporary utilities, support facilities, and security and protection facilities.
- B. Temporary utilities include, but are not limited to, the following:
1. Sewers and drainage.
 2. Water service, metering, and distribution.
 3. Sanitary facilities, including toilets, wash facilities, and drinking-water facilities.
 4. Heating and cooling facilities.
 5. Ventilation.
 6. Electric power service.
 7. Electric power service – temporary backup generator.
 8. Lighting.
 9. Telephone service
- C. Support facilities include, but are not limited to, the following:
1. Temporary roads, paving and markings
 2. Excavation support, shoring and temporary bridging.
 3. Wash racks.
 4. Dewatering facilities and drains.
 5. Project identification and temporary signs.
 6. Waste disposal facilities.
 7. Field offices.
 8. Storage and fabrication sheds.
 9. Lifts and hoists.
 10. Temporary stairs and ramps.
 11. Construction aids and miscellaneous services and facilities.
- D. Security and protection facilities include, but are not limited to, the following:
1. Environmental protection.
 2. Stormwater, sediment, and erosion controls control.
 3. Tree, plant, and animal protection.
 4. Pest control.
 5. Site enclosure fence (maintenance of and modifications to existing).
 6. Security enclosure and lockup.
 7. Additional Security for Special Events.
 8. Barricades, warning signs, and lights. This includes traffic control on the North Road as well as interior systems.
 9. Covered walkways.
 10. Temporary enclosures.
 11. Temporary partitions.
 12. Noise control.
 13. Weather protection.
 14. Fire protection.

15. Sediment and erosion control, including permit.

E. Related Requirements:

1. Section 011000 "Summary" for work restrictions and limitations on utility interruptions.
2. Section 312319 "Dewatering" for disposal of ground water at Project site.
3. Section 321216 "Asphalt Paving" for construction and maintenance of asphalt pavement for temporary roads and paved areas.
4. Section 321313 "Concrete Paving" for construction and maintenance of cement concrete pavement for temporary roads and paved areas.
5. Division 01 Section 013100 "Project Management and Coordination" for additional Site Utilization Plan submittal requirements.
6. Division 01 Section 013300 "Submittal Procedures" for procedures for submitting copies of implementation and termination schedule and utility reports.
7. Division 01 Section 017300 "Execution Requirements" for progress cleaning requirements.

1.3 DEFINITIONS

- A. Permanent Enclosure: As determined by the COTR, permanent or temporary roofing is complete, insulated, and weather tight; exterior walls are insulated and weather tight; and all openings are closed with permanent construction or substantial temporary closures.

1.4 USE CHARGES

- A. General: Cost or use charges for temporary facilities are not chargeable to the Smithsonian Institution and shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including, but not limited to, the following:
1. SI Staff and construction forces.
 2. Occupants of Project.
 3. SI-provided office trailers.
 4. SI's designated parking.
 5. Testing agencies.
 6. Personnel of authorities having jurisdiction.
 7. Storm Water Management Permit Fees
- B. Utilities: SI will provide all utility services. Contractor is responsible for all temporary connections, load sizing and protection based upon available service and full restoration of any changes to permanent utilities. The contractor shall implement basic conservation measures, otherwise they will be charged for utility usage.
- C. General: Installation and removal of and use charges for temporary facilities shall be included in the Contract Sum unless otherwise indicated. Allow other entities to use temporary services and facilities without cost.
- D. Water and Sewer Service from Existing System: Water from Owner's existing water system is available for use without metering and without payment of use charges. Provide connections, extensions and temperature protection of services as required for construction operations.
- E. Electric Power Service from Existing System: Electric power from Owner's existing system is available for use without metering and without payment of use charges. Provide connections and extensions of services as required for construction operations per code requirements.

1.5 INFORMATIONAL SUBMITTALS

- A. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.
- B. Erosion and Sedimentation-Control Plan: Show compliance with requirements of EPA Construction General Permit or authorities having jurisdiction, whichever is more stringent.
- C. Fire-Safety Program: Show compliance with requirements of NFPA 241 and authorities having jurisdiction. Indicate Contractor personnel responsible for management of fire-prevention program.
- D. Moisture-Protection Plan: Describe procedures and controls for protecting materials and construction from water absorption and damage.
 - 1. Describe delivery, handling, and storage provisions for materials subject to water absorption or water damage.
 - 2. Indicate procedures for discarding water-damaged materials, protocols for mitigating water intrusion into completed Work, and replacing water-damaged Work.
 - 3. Indicate sequencing of work that requires water, such as sprayed fire-resistive materials, plastering, and terrazzo grinding, and describe plans for dealing with water from these operations. Show procedures for verifying that wet construction has dried sufficiently to permit installation of finish materials.
- E. Dust- and HVAC-Control Plan: Submit coordination drawing and narrative that indicates the dust- and HVAC-control measures proposed for use, proposed locations, and proposed time frame for their operation. Identify further options if proposed measures are later determined to be inadequate. Include the following:
 - 1. Locations of dust-control partitions at each phase of work.
 - 2. HVAC system isolation schematic drawing.
 - 3. Location of proposed air-filtration system discharge.
 - 4. Waste handling procedures.
 - 5. Other dust-control measures.
- F. Implementation and Termination Schedule: Within 15 days of date established for submittal of Contractor's Construction Schedule, submit a schedule indicating implementation and termination of each temporary utility.
- G. Plan for Construction Facilities, Temporary Controls, and Protection of the Site, to be part of the Site Utilization Plan per Section 013100 "Project Management and Coordination" and as stated

below: Submit a Plan that both graphically and narratively describes the proposed facilities, temporary controls, and protection of the site to the COTR for approval no less than 5 working days prior to the Preconstruction Conference. The plan shall address construction sequencing as required by Section 011000 "Summary", Article 1.5A Work Sequence. At a minimum, include the following in the Plan:

- 1. Proposed method, location, materials, and construction of temporary structures, facilities, walkways, utilities, field offices, storage sheds, trailers, toilet facilities, storage areas, fencing, enclosures, barriers, dust/noise partitions, identification and directional signage, and other temporary controls.
 - a. Provide approved and appropriate barriers for the protection and containment of the animal collection if applicable.
- 2. Routes of vehicular and pedestrian access and egress for Contractor personnel, SI personnel, the public (where applicable), including those for people with disabilities (where applicable), including temporary striping where required.
- 3. Location and maintenance of emergency exits.

4. Methods of protection of existing surfaces, occupants, utilities, and other SI property, including protection of existing historic fabric and the North Road.
5. Means of connection of temporary enclosures/controls to existing historic materials.
6. Incorporating all existing site conditions and constraints.

Traffic Control Plan per Manual on Uniform Traffic Control Devices (U.S. Department of Transportation, Federal Highway Administration, latest edition) to maintain at a minimum one single lane of synchronized traffic at all times. The plan shall address barricade size, type and configuration, the minimum lane width (13'), controlled Contractor access into the work zone, any barricade cones or barrels before the traffic barricades, signage, temporary lane markings, The traffic control plan shall be prepared and signed by a Licensed Professional Engineer in the District of Columbia.

- H. Material Safety Data Sheets (MSDS): Submit Material Safety Data Sheets for all toxic and/or hazardous substances proposed for temporary controls prior to use of any such substances. Submit NZP material approval request form and required data for all hazardous materials.
- I. Professional Project Sign: Submit a shop drawing indicating proposed construction, mounts and or posts, materials, colors, font, letter sizes, graphics, etc. to scale of the required Project Sign.

1.6 QUALITY ASSURANCE

- A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.
- B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.
- C. Accessible Temporary Egress: Comply with applicable provisions in the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1
- D. Standards: Comply with ANSI A10.6, NECA's "Temporary Electrical Facilities," and NFPA 241.
 1. Trade Jurisdictions: Assigned responsibilities for installation and operation of temporary utilities are not intended to interfere with trade regulations and union jurisdictions.
 2. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.
- E. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

1.7 PROJECT CONDITIONS

- A. Temporary Use of Permanent Facilities: Engage Installer of each permanent service to assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.
- B. Conditions of Use: The following conditions apply to use of temporary services and facilities by all parties engaged in the Work

1. Keep temporary services and facilities clean and neat. Operate in a safe and efficient manner.
 2. Relocate temporary services and facilities as required by progress of the Work.
 3. Take necessary fire-prevention measures.
 4. Do not allow hazardous, dangerous, or unsanitary conditions, or public nuisances to develop or persist on site.
 5. Take measures to prevent rodent infestation of waste and stored materials. Empty food trash daily.
 6. Comply with Division 01 Section "Indoor Air Quality Requirements."
- C. Sanitary Facilities: Contractor personnel may not use existing Smithsonian restrooms on the premises. Provide temporary facilities on site in accordance with requirements set forth in Parts 2 and 3 below.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Chain-Link Fencing: Minimum 2-inch, 0.148-inch-thick, galvanized-steel, chain-link fabric fencing; minimum 6 feet high required at the Limits of Disturbance perimeter with galvanized-steel pipe posts; minimum 2-3/8-inch-OD line posts and 2-7/8-inch-OD corner and pull posts, with 1-5/8-inch-OD top rails. Gates and posts are to be mounted into the ground.
 - a. Wrap the entire fence with a printed fabric banner.
 - i. Banner content provided by Smithsonian Institution Exhibits
 - ii. Banner fabric density sufficiently open to prevent wind loads from exceeding 40 lbs. square foot.
- B. Polyethylene Sheet: Reinforced, fire-resistive sheet, 10-mil minimum thickness, with flame-spread rating of 15 or less per ASTM E 84 and passing NFPA 701 Test Method 2.
- C. Dust-Control Adhesive-Surface Walk-off Mats: Provide mats minimum 36 by 60 inches.
- D. Insulation: Unfaced mineral-fiber blanket, manufactured from glass, slag wool, or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively.
- E. General: Provide new materials. Undamaged, previously used materials in serviceable condition may be used if approved by the COTR. Provide materials suitable for use intended.
- F. Pavement: Comply with Division 32.
- G. Temporary backup generator including associated controls, wiring, cables, switchgear, and fuel as required.
- H. All temporary fences (like new) full height with printed images on fabric. Fence structure that is not used for animal containment or protection shall be supported to resist 40 mph winds.
- I. Standard SI Construction Fence: Install new, as needed, and maintain the existing standard SI construction fence as detailed on the Drawings.

2.2 TEMPORARY FACILITIES

- A. Field Offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading. Contractor to provide submission for COTR's approval. Contractor responsible for all temporary connections.
- B. Storage and Fabrication Sheds: Provide sheds sized, furnished, and equipped to accommodate

materials and equipment for construction operations.

1. Store combustible materials apart from building. (Submit for COTR approval)

2.3 EQUIPMENT

- A. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.
- B. HVAC Equipment: Unless Owner authorizes use of permanent HVAC system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.
 1. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
 2. Heating Units: Listed and labeled for type of fuel being consumed, by a qualified testing agency acceptable to authorities having jurisdiction and marked for intended location and application.
 3. Permanent HVAC System: If Owner authorizes use of permanent HVAC system for temporary use during construction, provide filter with MERV of 8 at each return-air grille in system and remove at end of construction and clean HVAC system as required in Section 017700 "Closeout Procedures".
- C. Air-Filtration Units: Primary and secondary HEPA-filter-equipped portable units with four-stage filtration. Provide single switch for emergency shut off. Configure to run continuously.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.
 1. Locate facilities to limit site disturbance as specified in Section 011000 "Summary."
- B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of complete permanent facilities.

3.2 TEMPORARY UTILITY INSTALLATION

- A. General: Install temporary service or connect to existing service.
 1. Arrange with utility company, COTR, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services.
- B. Sewers and Drainage: If sewers are available, provide temporary connections to remove effluent that can be discharged lawfully. If sewers are not available or cannot be used, provide drainage ditches, dry wells, stabilization ponds, and similar facilities. If neither sewers nor drainage facilities can be lawfully used for discharge of effluent, provide containers to remove and dispose of effluent off-site in a lawful manner.
 1. Filter out excessive soil, construction debris, chemicals, oils, and similar contaminants that might clog sewers or pollute waterways before discharge.
 2. Connect temporary sewers to municipal system as directed by sewer department officials.

3. Maintain temporary sewers and drainage facilities in a clean, sanitary condition. After heavy use, restore normal conditions promptly.
 4. Provide temporary filter beds, settlement tanks, separators, and similar devices to purify effluent to levels acceptable to authorities having jurisdiction.
- C. Water Service: Install water service and distribution piping in sizes and pressures adequate for construction.
- D. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with requirements of authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.
- E. Heating and Cooling: Provide temporary heating and cooling required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment from that specified that will not have a harmful effect on completed installations or elements being installed.
1. Maintain a minimum temperature of 50 deg F in permanently enclosed portions of building for normal construction activities, and 65 deg F for finishing activities and areas where finished Work has been installed.
 2. Maintain a maximum temperature of 95 deg F in permanently enclosed portions of building for normal construction activities, and 86 deg F for finishing activities and areas where finished Work has been installed.
- F. Ventilation and Humidity Control: Provide temporary ventilation required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of high humidity as specified in the documents. Select equipment from that specified that will not have a harmful effect on completed installations or elements being installed. Coordinate ventilation requirements to produce ambient conditions required and minimize energy consumption.
- G. Electric Power Service: Connect to Owner's existing electric power service. Maintain equipment in a condition acceptable to Owner. Electric Power Service: Provide weatherproof, grounded electric power service and distribution system of sufficient size, capacity, and power characteristics during construction period. Include meters, transformers, overload-protected disconnecting means, automatic ground-fault interrupters, and main distribution switchgear.
- H. Temporary Power Service: Provide temporary power generator as required by the Contractor to complete the Work.
1. Install temporary backup power distribution cabling and wiring overhead; rise vertically where least exposed to damage.
 2. Install temporary backup power generator controls and switchgear where least exposed to damage.
- I. Electric Distribution: Provide receptacle outlets adequate for connection of power tools and equipment.
1. Provide waterproof connectors to connect separate lengths of electrical power cords if single lengths will not reach areas where construction activities are in progress. Do not exceed safe length- voltage ratio or manufacturer recommendations.
 2. Provide warning signs at power outlets other than 110 to 120 V.
 3. Provide metal conduit, tubing, or metallic cable for wiring exposed to possible damage. Provide rigid steel conduits for wiring exposed on grades, floors, decks, or other traffic areas.

4. Provide metal conduit enclosures or boxes for wiring devices.
 5. Provide 4-gang outlets, spaced so 100-foot extension cord can reach each area for power hand tools and task lighting. Provide a separate 125-V ac, 20-A circuit for each outlet.
- J. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations and traffic conditions.
1. Install and operate temporary lighting that fulfills security, emergency egress, and protection requirements without operating entire system. (1 foot candle)

3.3 SUPPORT FACILITIES INSTALLATION

A. General: Comply with the following:

1. Locate field offices, storage sheds, sanitary facilities, and other temporary construction and support facilities for easy access within the approved designated areas.
2. Provide incombustible construction for offices, shops, and sheds located within construction area or within 30 feet of building lines. Comply with NFPA 241.
3. Maintain support facilities until near Substantial Completion. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use

permanent facilities, under conditions acceptable to the COTR.

B. Traffic and Pedestrian Controls: Provide temporary traffic controls at junction of temporary roads with public roads. Include warning signs for public traffic and "STOP" signs for entrance onto public roads.

1. Provide safety barricades in accordance with the District of Columbia Building Code and applicable OSHA regulations. Provide barricades, subject to the approval of the COTR, to deter passage of persons and/or vehicles into construction areas as specified or necessary.
2. When construction activities impact on the public right-of-way (e.g., public sidewalks), provide barricades as necessary to create a safe passage for pedestrians around the obstacles and separate from vehicular traffic lanes. Provide appropriate directional signs and certified signalers.
3. See Section 013100 "Project Management and Coordination" for Site Utilization Plan and Traffic Control Plan requirements.

C. Temporary Roads and Paved Areas: Construct and maintain temporary roads and paved areas adequate for construction operations. Locate temporary roads and paved areas **as indicated** on the Drawings.

1. Provide dust-control treatment that is nonpolluting and non-tracking. Reapply treatment as required to minimize dust.

D. Temporary Use of Permanent Roads and Paved Areas: Locate temporary roads and paved areas in same location as permanent roads and paved areas. Construct and maintain temporary roads and paved areas adequate for construction operations. Extend temporary roads and paved areas, within construction limits indicated, as necessary for construction operations.

1. Coordinate elevations of temporary roads and paved areas with permanent roads and paved areas.
2. Prepare subgrade and install subbase and base for temporary roads and paved areas according to Section 312000 "Earth Moving."

3. Recondition base after temporary use, including removing contaminated material, regrading, proof rolling, compacting, and testing.
 4. Delay installation of final course of permanent hot-mix asphalt pavement until immediately before Substantial Completion. Repair hot-mix asphalt case-course pavement before installation of final course according to Section 321216 "Asphalt Paving."
- E. Traffic Management to be provided by the Contractor.
1. Protect existing site improvements to remain including curbs, pavement, and utilities.
 2. Maintain access for fire-fighting equipment and access to fire hydrants.
 3. Address Public Pedestrian and Vehicle Traffic in vicinity of project
- F. Parking. NO PARKING areas for construction personnel will be provided on site or campus.
- G. Dewatering Facilities and Drains: Comply with requirements of authorities having jurisdiction. Maintain Project site, excavations, and construction free of water.
1. Dispose of rainwater in a lawful manner that will not result in flooding Project or adjoining properties or endanger permanent Work or temporary facilities.
 2. Remove snow and ice as required to minimize accumulation and impairment of construction operations within the limits of construction.
- H. Project Signs: Provide Project signs as indicated. Unauthorized signs are not permitted.
- I. Project Identification and Temporary Signs: Prepare Project identification and other signs in sizes indicated. Install signs where indicated to inform public and persons seeking entrance to Project. Do not permit installation of any unauthorized signs. Submit all sign designs to the COTR for approval.
1. Engage an experienced sign painter to apply graphics for Project identification signs. Comply with details indicated.
 2. Prepare temporary signs to provide directional information to construction personnel and visitors.
 3. Construct signs of exterior-type Grade B-B high-density concrete form overlay plywood in sizes and thicknesses indicated. Support on posts or framing of preservative-treated wood or steel.
 4. Paint sign panel and applied graphics with exterior-grade alkyd gloss enamel over exterior primer.
 5. For project identification sign, see diagram at end of this Section for construction, materials, colors, required wording, and use of logos. Camera-ready artwork for logos will be provided by the COTR.
 6. Maintain and touchup signs so they are legible at all times.
- J. Waste Disposal Facilities: Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."
- K. Waste Disposal Facilities: Provide waste-collection containers in sizes adequate to manage waste from construction operations. Comply with requirements of authorities having jurisdiction. Comply with progress cleaning requirements in Section 017300 "Execution."
- L. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel.
1. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.

- M. Temporary Stairs, Boardwalks, and Ramps: Until permanent stairs are available, provide temporary stairs, boardwalks, or ramps where ladders or walkways are not adequate. Cover finished permanent stairs with protective covering of plywood or similar material so finishes will be undamaged at time of acceptance.

3.4 SECURITY AND PROTECTION FACILITIES INSTALLATION

- A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.
- B. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations that minimize possible air, waterway, subsoil contamination, pollution or other undesirable effects.
 - 1. Comply with work restrictions specified in Section 011000 "Summary."
- C. Temporary Erosion and Sedimentation Control: Comply with authorities having jurisdiction, Requirements specified in Section 311000 "Site Clearing."
- D. Temporary Erosion and Sedimentation Control: Provide measures to prevent soil erosion and discharge of soil-bearing water runoff and airborne dust to undisturbed areas and to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and the authorities having jurisdiction, whichever is more stringent.
 - 1. Based upon contract documents submit, pay fees, oversee, and maintain all related to Temporary Erosion and Sedimentation Control measures to comply with authorities having jurisdiction's requirements.
 - 2. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross tree- or plant- protection zones.
 - 3. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
 - 4. Clean, repair, and restore adjoining properties and roads affected by erosion and sedimentation from Project site during the course of Project.
 - 5. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.
- E. Stormwater Control: Comply with requirements of authorities having jurisdiction. Provide barriers in and around excavations and subgrade construction to prevent flooding by runoff of storm water from heavy rains.
- F. Tree and Plant Protection: Comply with requirements specified in Section 015639 "Temporary Tree and Plant Protection."
- G. Pest Control: Implement practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion.

Pest Control: ALL PEST CONTROL MUST BE COORDINATED WITH THE NZP PEST CONTROL OFFICER. Contractor shall follow Best Management Practices regarding site management and cleanup to minimize vermin or pest infestations for the duration of the project. No extermination materials are to be used on this project without the written approval of the NZP Pest Control Officer.

- H. Site Enclosure Fence: Before construction operations begin, furnish, and install site enclosure fence in a manner that will prevent people and animals from easily entering site except by entrance gates.

If fence needs to be modified or relocated to accommodate current construction activities, submit a request and description of modification to COTR at least 24 hours in advance.

1. Extent of Fence: As required to enclose entire Project site as indicated on Drawings.
 2. Maintain security and restrict access to authorized personnel only.
 3. Lock shall be a combination lock, not a keyed lock.
 4. Maintain security by limiting distribution of lock combination to authorized personnel. Provide COTR with lock combination.
- I. Security Enclosure and Lockup: Install temporary enclosure around partially completed areas of construction. Provide lockable entrances to prevent unauthorized entrance, vandalism, theft, and similar violations of security. Lock entrances at end of each workday.
- J. Barricades, Warning Signs, and Lights: Comply with standards and code requirements for erecting structurally adequate barricades. Paint with appropriate colors, graphics, and warning signs to inform personnel and public of possible hazard. Where appropriate and needed, provide lighting, including flashing red or amber lights. Provide easily identifiable, accessible walkways around construction activities and obstacles. Post directional signs at decision points to prevent unnecessary travel along changed routes and to dead ends. Erect and dismantle barriers in phases so that a clear route is always available. Provide security hardware on doors to construction areas to prevent entry by unauthorized persons.
1. For exterior safety barriers, sidewalk bridges, and similar uses, provide minimum 5/8-inch-thick exterior plywood and structurally appropriate dimensional lumber. Provide appropriate supports to prevent overturning. Paint both sides and maintain in good condition, repainting as necessary, for the duration of use.
- K. Temporary Egress: Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.
- L. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. For IT equipment to remain in the Police Station basement.
- M. Scaffolding and Platforms: Erect temporary scaffolding in accordance with OSHA 29 CFR 1926.451 and ANSI A10.8.
1. Provide landing platforms with stairways or ladders for proper access and egress to and from all work areas.
 2. For all frame scaffolding greater than 13 feet in height, submit shop drawings, signed, and sealed by a Professional Engineer registered and licensed in jurisdiction of the project, to the COTR a minimum of 10 working days prior to erection.
 3. During non-working hours, close and lock scaffolding with a physical barrier to prevent Access by unauthorized persons.
 4. Submit daily installation inspection documentation, signed by qualified personnel
- N. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weather tight enclosure for building exterior.
1. Temporary enclosures for people (public and non-public).
 - a. Where heating or cooling is needed and permanent enclosure is not complete, provide insulated temporary enclosures. Coordinate enclosure with ventilating and material drying or curing requirements to avoid dangerous conditions and effects.
 - b. Vertical Openings: Close openings of 25 sq. ft. or less with plywood or similar materials.

- c. Horizontal Openings: Close openings in floor or roof decks and horizontal surfaces with load bearing, wood-framed construction.
 - d. Install tarpaulins securely using fire-retardant-treated wood framing and other materials.
 - e. Where temporary wood or plywood enclosure exceeds 100 sq. ft. in area, use fire- Retardant-treated material for framing and main sheathing.
- O. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241.
- 1. Provide fire extinguishers, installed on walls on mounting brackets, visible and accessible from space being served, with sign mounted above.
 - a. Contractor Field Offices: Class A stored-pressure water-type extinguishers.
 - b. Other Locations: Class ABC dry-chemical extinguishers or a combination of extinguishers of NFPA-recommended classes for exposures.
 - c. Locate fire extinguishers where convenient and effective for their intended purpose; provide not less than one extinguisher per work area and near each entry

And exit.

- 2. Store combustible materials in containers in fire-safe locations.
- 3. Maintain unobstructed access to fire extinguishers, fire hydrants, temporary fire- protection facilities, stairways, and other access routes for firefighting. Prohibit smoking in hazardous fire-exposure areas.
- 4. Supervise welding operations, combustion-type temporary heating units, and similar Sources of fire ignition.
- 5. Develop and supervise an overall fire-prevention and first-aid fire-protection program for personnel at Project site. Review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.
- 6. Provide hoses for fire protection of sufficient length to reach construction areas. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.

3.5 MOISTURE AND MOLD CONTROL

- A. Contractor's Moisture-Protection Plan: Avoid trapping water in finished work. Document visible signs of mold that may appear during construction.
- B. Exposed Construction Phase: Before installation of weather barriers, when materials are subject to wetting and exposure and to airborne mold spores, protect as follows:
 - 1. Protect porous materials from water damage.
 - 2. Protect stored and installed material from flowing or standing water.
 - 3. Keep porous and organic materials from coming into prolonged contact with concrete.
 - 4. Remove standing water from decks.
 - 5. Keep deck openings covered or dammed.
- C. Partially Enclosed Construction Phase: After installation of weather barriers but before full enclosure and conditioning of building, when installed materials are still subject to infiltration of moisture and ambient mold spores, protect as follows:
 - 1. Do not load or install drywall or other porous materials or components, or items with high organic content, into partially enclosed buildings.
 - 2. Keep interior spaces reasonably clean and protected from water damage.
 - 3. Periodically collect and remove waste containing cellulose or other organic matter.

4. Discard or replace water-damaged material.
5. Do not install material that is wet.
6. Discard, replace, or clean stored or installed material that begins to grow mold.
7. Perform work in a sequence that allows any wet materials adequate time to dry before enclosing the material in drywall or other interior finishes.

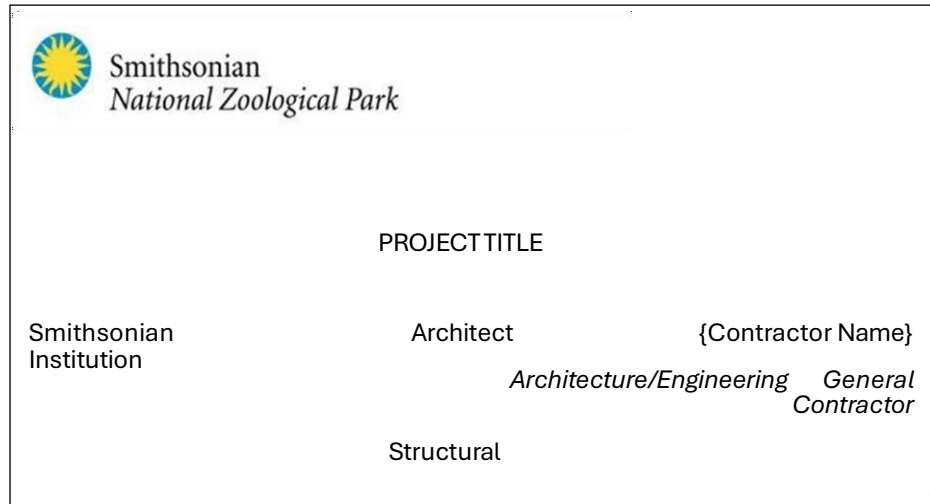
3.6 OPERATION, TERMINATION, AND REMOVAL

- A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.
- B. Maintenance: Maintain facilities in good operating condition until removal.
 1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.
- C. Operate Project-identification-sign lighting daily from dusk until 12:00 midnight.
- D. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Substantial Completion.
- E. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facilities. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 1. Materials and facilities that constitute temporary facilities are property of Contractor. Owner reserves right to take possession of Project identification signs.
 2. Remove temporary roads and paved areas not intended for or acceptable for integration into permanent construction. Where area is intended for landscape development, remove soil and aggregate fill that do not comply with requirements for fill or subsoil. Remove Materials contaminated with road oil, asphalt and other petrochemical compounds, and other substances that might impair growth of plant materials or lawns. Repair or replace street paving, curbs, and sidewalks at temporary entrances, as required by authorities having jurisdiction.
 3. At Substantial Completion, repair, renovate, and clean permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 017700 "Closeout Procedures."

3.7 PROJECT SIGN

- A. Contractor shall provide two signs (4 feet by 8 feet) installed on posts sufficient to resist 40 mph winds without damage. All materials used shall be exterior grade quality, be resistant to direct sun and ultraviolet light, and designed to last a minimum of five years.
- B. In the event a sign is damaged or fades during the contract period, provide a new replacement sign. Contractor will also be responsible for any required sign relocation due to site conditions.
- C. See sketch of sample sign below. Layout of sign to be approved by COTR prior to

installation. Locate installed sign as directed by COTR.



Sample Sign (8 feet x 4 feet)

END OF SECTION 015000

SECTION 01 5639 - TEMPORARY TREE AND PLANT PROTECTION**PART 1 - GENERAL****1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division I Specifications Sections, apply to this Section.

1.1 SUMMARY

- A. This Section includes the protection and stress reduction of existing trees and vegetation that interfere with, or are affected by, execution of the work, whether temporary or permanent. Work is to be coordinated with Site & Landscape Improvements and Tree Preservation Plan. Refer to the Tree Protection Action Key (TPAK) to referencing pertinent work for each tree. Not every application is relevant on this site currently.

- B. The following specifications apply to work of the Contract Arborist related to Protection and Stress Reduction Measures and coordination and oversight of the Tree Protection and Preservation Program by the Design Team Arborist. This work includes but is not limited to the following:

1. Submittals from the General Contractor
2. Pre- Construction Meeting and Onsite Monitoring of Tree Preservation.
3. Selective tree removals for "Removal by Arborist" (RBA) (Contract Arborist) Within Tree Protection Areas (TPAs).
4. Temporary Site and Tree protection fencing and temporary sign installation
5. Root Protection Matting for temporary construction access in TPAs
6. Composted Mulching
7. Liquid subsurface fertilization
8. Tree Growth Regulator (Paclobutrazol)
9. Soil Nutrient Testing
10. Super Silt Fence / Silt Fence "Trenchless Attachment" to Root Protection Matting (RPM) and Root Aeration Matting (RAM)
11. Temporary Limb Guying or Clearance Pruning for construction access
12. Seasonal Supplemental Watering
13. Monitoring and Treatment of Tree Health
14. Supersonic Air Tool (SSAT) and Hand Excavation within the Critical Root Zones (CRZs)

1.1 DEFINITIONS

- A. Certified Arborist: Credential of an individual arborist issued and administered by the International Society of Arboriculture (ISA). This credential must be current and valid to qualify to use the copyrighted designation of "Certified Arborist". Refer to www.isa-arbor.com for additional information.

B. Design Team Arborist: Consulting firm contracted to provide planning and design services, technical assistance and advice to the COTR and design team. Duties include but are not limited to the following: design phase tree inventories, assessments, and root investigations, etc.; develop tree preservation plans, methods, details and specifications; and provide site monitoring, construction submittal document review, and monitoring of the Contract Arborist. Design Team Arborist is contracted directly to the Issues.

- C. Contract Arborist: Arboricultural contracting firm implementing the approved tree preservation plans on site. All crews conducting arboricultural operations on site shall consist of at least one Certified Arborist who directly oversees all work by that crew. Arboricultural operations include, but are not limited to, pruning, tree protection device installation and maintenance (fence, matting, etc.), root pruning, air tool root excavation/exploration (SSAT), soil care activities, soil testing, mulch application, tree inspections, pesticide/chemical applications and tree removal. Special qualifications submittal is required for review and approval below. Contract Arborist will be sub-contracted by the general contractor or COTR, at the COTR's discretion.
- D. Tree Protection Area (TPA): Area indicated on Drawings surrounding individual trees or groups of trees to be protected during construction.
- E. Critical Root Zone (CRZ): Area shown on Drawings for all trees within scope of this project with a circle. Estimated area is based upon an industry standard "rule of thumb" of 1.5 feet of radius per inch of diameter at breast height (DBH). CRZ is described as the minimum area of tree roots required to be protected to maintain tree health. Any impact within the CRZ must be mitigated based on severity up to and including tree removal if the impact or disturbance is severe.
- F. Tree Protection Action Key (TPAK): Matrix provided on Plan sheets for each tree indicating designated protection and stress reduction measures specified in this document.
- G. Supersonic Air Tool (SSAT): Handheld tool designed to focus highly compressed air (90-125 psi) provided from a large air compressor (185-375 cfm) at speeds close to 1400 mph at the tip of the tool. Widely used by arboricultural firms and consultants for multiple purposes including but not limited to: root collar investigation, CRZ investigation, root pruning (especially large roots > 1.5" diameter or where existing underground cables or conduits are located), radial mulching and restoration of compacted soils, excavation for utilities within protected CRZs to minimize root damage from construction.
- H. Tree Removal by Arborist: Action whereby the Contract Arborist removes trees designated for "Removal by Arborist" selected from inside the TPAs. Trees shall be taken down by hand sectionally or fall directionally to minimize damage to adjacent tree canopies, root systems, or adjacent structures. Roots and stump are not disturbed unless so designated in TPAK.
- I. Root Pruning: Action indicated on Drawings to provide a more suitable cut for protected tree roots to minimize ripped or torn roots during excavations and grading with standard construction equipment. Various methods may be used as specified.
- K. Root Protection Mat (RPM): The purpose of the temporary RPM is to reduce compaction, rutting, and contamination of soils and root systems of trees to be retained should staging, temporary stockpile, or equipment access be required within the CRZ areas due to extreme site constraints.
 - 1. RPM shall be used for all access within CRZ areas of trees to remain. Matting is not required where existing pavement or concrete will remain undisturbed.
- L. Mulching of Trees: Application of a wood mulch product to areas surrounding designated trees. Mulch

increases moisture-holding capacity, helps mitigate soil compaction, and increases soil organic composition needed.

- M. Soil Amendments: Various product components applied to existing soil environment of protected trees, as indicated on Plan notes.
- N. Tree Growth Regulator (*Paclobutrazol*): Products applied to designated trees used to regulate plant growth in such a way as to restrict canopy growth and free stored or produced energy for other uses in the tree. For highly impacted trees, more energy may be made available for fibrous root growth (to

combat root loss), thicker darker leaves (allowing for increased photosynthesis, and increased drought tolerance), and pest tolerance (often an issue with construction stressed trees), among other potential benefits.

O. Limits of Disturbance (LOD) (also called Limits of Construction): Specific outer limits of all construction activities for the entire project.

P. DBH (Diameter at Breast Height): Tree trunk diameter measured at 4.5 feet above grade.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings for specific protection work within tree critical root zones. These are as follows.
 - a) Root protection matting
 - b) Method of supplemental watering for tree protection areas.
- C. Documentation of work: For each phase, the Contract Arborist shall document that for each tree designated to remain, the required protection measures have been implemented prior to or during construction according to construction documents.
- D. Qualification Data: For Contract Arborist Firm Qualifications, submit firm and individual qualifications as follows.
 - a) Submit a minimum of two resumes and detailed qualifications from staff or team individuals assigned to this project as detailed under Quality Assurance below. Due to the complexity of this project, standard arboricultural experience may not qualify.
 - b) Provide references for above from a minimum of three commercial, non-governmental or governmental projects for whom similar tree preservation programs have been successfully implemented. Include the following information:
 - a. Project name, size and scope
 - b. Number and principal species of trees involved.
 - c. Relevant photos or aerials.
 - d. Tree preservation budget.
 - e. Scope of services provided.
 - f. Name and contact for project COTR, designer, or contractor.
- E. Pedestrian/Property Protection Plan: Contract Arborist to submit a written plan describing all protective measures proposed to be used to minimize potential impact to pedestrians, parked cars, workers and other public and private property.
 - a) Protection measures shall be required for all on-site tree care activities including but not limited to Supersonic Air Tool excavation, root pruning, canopy pruning, etc.
- F. Maintenance Prescription: Design Team Arborist (or Contract Arborist) shall submit seasonal/monthly recommendations for maintenance and stress reduction measures as a result of construction, changes in weather patterns or events, and response in health from individual trees during and after completing the work.
- G. Soil Samples: Submit soil sample for analysis during site work phase of this project. Take the samples between April through October. The sample shall be a combined mix of

representative soil samples from all areas of protected trees (landscape areas and street tree planting pits where pertinent). Samples and procedures per local cooperative extension shall be followed. Forward reports to Architect and Project Arborist.

- H. Soil Amendments: Contract Arborist shall submit specific fertilizer formulations, application rates and methods for review by Project Arborist. All fertilization and soil amendments shall be in conformance with soil test results.
- I. Site Documentation: Submit monthly reports to COTR and Project Arborist containing documentation of all tree protection work for each tree. These activities include but not limited to root pruning, tree protection fencing, excavation within critical root zones, temporary root protection or root aeration matting. Documentation shall include tree numbers of trees and plan markup. Representative photos of each activity are also required.
- J. Existing Conditions: Upon installation of designated protection measures the Contract Arborist shall submit documentation of existing trees and plantings indicated to remain, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.
 - a) Use sufficiently detailed photographs, tree numbers, or videotape.
 - b) Include plans and notations to indicate specific prior wounds, root disturbance, damage, or conditions of each tree or other plants designated to remain.

1.3 QUALITY ASSURANCE

- A. On-site Arborist (individual) Qualifications: An arborist certified by the International Society of Arboriculture (ISA) and licensed in the jurisdiction where project is located. All work performed by Contract Arborist including any oversight and documentation work, shall be performed or directly supervised by at least one on-site arborist with these minimum qualifications.
- B. Contract Arborist Firm Qualifications:
 - 1. Established business with documented experience of at least five years.
 - 2. Experience working on a minimum of three commercial, nongovernmental or governmental projects where similar tree preservation programs have been successfully implemented.
 - 3. Properly licensed and insured to perform arboricultural work in the jurisdiction where the project is located.

Provide names of each individual to comply with the following:

- 4. Minimum BS or AS degree in forestry, arboriculture, or related field.
- 5. Certification by ISA (Certified Arborist or Board-Certified Master Arborist).
- 6. Maryland Licensed Tree Expert # as pertinent.
- 7. TRAQ qualifications.
- 8. Resumes should reflect combined 10 years' full-time experience on similar tree preservation projects.
- 9. Provide individual(s) names, certifications, and each anticipated role in this project. "Role(s)"

shall be defined as one or more of the following:

- a) Project Manager
- b) Technical oversight
- c) Field Arborist / Technician

For each staff member, list a minimum of three construction projects and a minimum three years' experience in the following technical applications:

10. Soil amendment prescriptions and applications.
11. Supersonic Air Tool Excavations for underground utilities equal to or exceeding 24" depth.
12. Root Protection Matting or similar applications.
13. Construction oversight and monitoring on large projects.
14. Coordination of arboricultural activities with construction project managers on large projects.

- C. Publications listed herein are part of this work to extent referenced:
 - a) ANSI A300 Standard Practices for Trees, Shrubs, and Other Woody Plant Maintenance
 - b) Part 1-2001, Tree Pruning;
 - c) Part 2-3004, Fertilization;
 - d) Part 3-2000, Cabling, Bracing, Guying of Established Trees;
 - e) Part 4-2002, Lightning Protection Systems.
 - f) ANSI Z133.1 - 1994 and most recent updates, Tree Care Operations - Safety Requirements
- D. Fertilizer and pesticides will be applied in strict accordance with the manufacturers label instructions and applicable federal, state, and local requirements. Fertilizer, soil conditioners, and pesticide applications must be approved by the COTR prior to application. Material Safety Data Sheets (MSDS) will be available for fertilizers and pesticides in the Contract Arborists' possession while on the site.
- E. Preconstruction Meeting: Conduct meeting at the project site prior to commencement of any project related site activities.
 1. Contract Arborist, Design Team Arborist, Project Design Team, COTR and Contractors shall attend. As well as the local agency inspector as applicable.
 2. Walk the site limits to review methods and procedures related to tree protection and preservation including, but not limited to, the following:
 - a) Construction schedule - verify availability of materials, personnel, and equipment needed to make progress and avoid delays.
 - b) Enforcement of requirements for tree protection areas.
 - c) Responsibilities of all parties, including coordination, access and timing requirements.
 - d) Field quality control.
 - e) Mark tree removals
 - f) Review and mark locations of root pruning, root protection mat-ting, and special demolition within tree protection areas.
 - g) Review sequencing of demo and excavation work near trees.
 - h) Review location and sequencing of shoring for excavation near trees.

1.4 PROJECT CONDITIONS

- A. The following practices are prohibited within all tree protection areas except as specifically indicated herein:
 - a) Storage or stockpiling of construction materials, chemicals, debris, or excavated materials
 - b) Parking vehicles, trailers or equipment
 - c) Foot traffic
 - d) Erection of sheds or structures
 - e) Impoundment or discharge of water

- f) Excavation or other digging unless otherwise indicated
 - g) Attachment of signs or other materials to, or wrapping materials around trees or plants unless otherwise indicated
- B. Do not direct vehicle or equipment exhaust toward protection zones.
- C. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Temporary Light Duty Root Protection Matting (RPM): geo-composite material comprised of a tri-planar geonet structure with thermally bonded nonwoven geotextiles on both sides.
- 1. Material shall be SynTec ROADRAIN T-7 or approved equivalent.
 - 2. For short duration applications (1-2 pass/1-3 day or less), AlturMATs® or 1” thick steel plates may be used in lieu of RPM.
 - 3. Submit shop drawings / cut sheets and material samples for review by Project Arborist and project civil.
- B. Temporary Trunk/Limb Protection Wrap: to provide specific protection to tree trunks when construction activities are expected to be in proximity.
- 1. Material shall be SynTec ROADRAIN T-7 or approved equivalent.
 - 2. Alternative methods and materials may be submitted for review.
 - 3. Chain-Link Fence: Galvanized steel chain-link fence fabric of 10 - 12-gauge wire fabric; 6 feet high; with 1.9-inch- diameter line posts; 2-3/8 inch - diameter terminal and corner posts; with tie wires, hog ring ties, gates, and other accessories for a temporary fence system.
 - 4. Site Fence: Exact specifications per civil specifications.
 - 5. Welded Wire Fence: 48” height, 14 gauge, 4’ x2” galvanized fabric with 6’ steel T-posts, metal wire clips, tree protection signs.
- C. Woven Silt Tube: A three-dimensional tubular sediment control and storm water runoff filtration device typically used for perimeter control of sediment and soluble pollutants (such as phosphorus and petroleum hydrocarbons), on and around construction activities. This method of sediment control provides a non-invasive approach when used within tree protection zones there is no root disturbance.
- 1. Refer to manufacturer’s instructions for materials and installation: www.fil-trex.com or equivalent.
- D. Wood Chip Mulch
- 1. Double ground whole tree hardwood aged a minimum 6 months from production, free from deleterious materials. Green chips or mulch aged less than 6 months shall not be used. Walnut mulch shall not be used. Submittal shall include original material source(s), number and type of grindings/chippings, duration of aging, timing of turning /aeration.
- E. Hardwood Destructive Borer /Beetle Control: Bifenthrin, such as *Onyx* or equivalent. Applied per label.
- F. Tree Growth Regulator (*Paclobutrazol*)
- 1. Paclobutrazol is a compound used to regulate plant growth in such a way as to restrict canopy

growth and free stored or produced energy for other uses in the tree. For highly impacted trees, this means more energy may be made available for fibrous root growth (to combat root loss), thicker darker leaves (allowing for increased photosynthesis, and increased drought tolerance), and pest suppression (often an issue with construction stressed trees); among countless other potential benefits. Trade name Cambistat® or equal.

G. Soil Care/Soil Amendments

1. Fertilizer and soil amendment selection shall be based upon soil test results and recommendations.

PART 3 - EXECUTION

1.1 TREE REMOVAL

- A. All trees and shrubs or hedges designated for removal shall be marked red for review and approval by COTR.
- B. All trees designated for removal, shall be taken down sectionally, or directionally felled to minimize damage to adjacent tree canopies or root systems by a qualified Contract Arborist. Gouges in turf from impacts shall be filled with topsoil and seeded at the direction of the COTR. Damage to adjacent trees shall be reviewed by Project Arborist and COTR for remedial recommendations or replacement.
- C. All work shall be done by hand, bucket truck, or crane operated equipment.
- D. Motorized equipment shall operate on existing pavement and not enter tree preservation areas without prior approval. Temporary root protection matting may be required for such access to prevent rutting and compaction.
- E. Stumps shall be ground to 8" below grade and grindings raked and removed from site; backfill holes with approved topsoil and mulch or seed per COTR. Coordinate with underground utilities locators prior to grinding. All stump grinding shall be performed by the Contract Arborist.
 1. For tree pits where a new tree is proposed, the stump may be ground out completely (as determined by the Contract Arborist) to allow the proposed tree to be planted. Backfill as above.
 2. Only trees with stumps within deep excavations may have stumps removed by excavator. Stump excavation to be performed by Site Contractor and under the direct supervision of the Contract Arborist.
- F. Removal of shrubs and hedges designated for removal for each phase shall be cut and stumps ground out or hand dug to remove stumps. Prior to removal, verify with COTR.
- G. Remove all wood debris from site promptly. All wood debris shall be removed each day unless directed otherwise by COTR.

1.2 TREE PROTECTION AND STRESS REDUCTION MEASURES -

1. General

- A. Refer to the TPAK and drawings sheet, detail sheet, and notes sheet for specific measures determined for each tree.

- B. Installation/implementation of the following measures shall be performed in the field by an ISA Certified Arborist as provided by the Contract Arborist.
 - C. All work, substitutions and/or modifications shall be subject to review and approval by the COTR and Project Arborist.
 - D. All work shall conform to applicable federal, state and local regulations and industry standards.
 - E. The Contract Arborist shall be responsible for all items in this section.
2. Coordination of Temporary Tree and Plant Protection. The work of the Contract Arborist coordination to include but not limited to the following:
- A. Existing underground utility marker conflicts brought to the attention of the Contractor for resolution as well uncovered underground utilities as a result of work.
 - B. Coordinate necessary survey layout of proposed construction elements in order to provide accurate locations for tree protection measures.
 - C. Layout location of designated tree protection based upon proposed construction and methods of construction for that area.
 - D. Site walk with Design Team Arborist and Site Superintendent to verify location of all tree protection measures prior to execution.
 - E. Notify Site Superintendent and Design Team Arborist if construction adjacent to tree protection does not appear to follow specifications or prior agreement or conflicts with tree protection seem eminent.
 - F. Coordinate with Site Superintendent, Construction Managers, COTR, and Security for access of deliveries, crews, equipment, start up, and clean-up of each item of work.
 - G. Provide "as built" of any change to location of tree protection.
 - H. Attend progress meetings as requested.
 - I. Provide submittals as required.
 - J. Notify Superintendent and Project Arborist of any breach or damage to tree protection requiring attention.
3. Temporary Tree Protection Fence
- A. Type and placement of fence to be designated on Plans and Details.
 - B. Attach tree protection area signs @ 30' spacing facing construction LOD.
- For fences lower than 6' in height, attach minimum 3 strips glow-flagging 2' long for each fence panel.
- C. Tree protection area signs shall be high visibility and all weather to last the duration of the project / Phase. Phone number of responsible contacts per- son shall be included on sign.
 - D. Install after root pruning if shown, and prior to demolition, clearing & excavation.
 - E. Install at 6"-12" outside (construction side) of the Root Prune line or within the Root Prune trench.
 - F. Silt fence will be outside (construction side) the tree protection fence; unless super silt fence is used in lieu of tree protection. Trenchless installation method shall be employed per Detail if Root Protection Matting is designated.
 - G. Exact placement of fence will be determined in walk through with Contractor, Project Arborist, Contract Arborist, Architect and COTR.
 - H. Sequencing of the tree protection fence will be determined during the initial site walk. In any case, no construction activities shall occur in each phase or section until approved protection is installed.
4. Root Protection Mat (RPM)
- A. The purpose of the RPM is to reduce compaction, rutting, and contamination of soils and root systems of trees to be retained should staging, temporary stockpile, or equipment access be required within the CRZ areas due to extreme site constraints.
 - B. RPM shall be used for all access within CRZ areas of trees to remain. Matting is not required where existing pavement or concrete will remain undisturbed.

- C. Shop drawings indicating the placement and types of panels and layers to be used, and method of removal shall be submitted.
- D. Light Duty RPM is for tree protection for construction access receiving temporary or minimally repetitive materials staging, foot traffic, or light equipment access within protected root zone. Wood chip mulch 2-3" may be installed under matting to further protect soils and roots if indicated on drawings.
- E. If short duration access is needed, such as one week or less, the use of "AlturnaMATS", 1" steel plate, or approved equal may be needed to avoid rutting and compaction. These materials may be shifted and re-used as work progresses.
- F. Medium Duty RPM for rubber tracked equipment access and staging is not anticipated to cause rutting. A combination of 4-6" wood chip mulch, triple-ply geocomposite, Alturnamats, steel plates or other matting can be used.
- G. Extreme Duty RPM is for all-weather staging, stockpile, or other repetitive construction operations may require 12" stone layer over RPM to allow heavy vehicles have the potential to cause dynamic compaction yet without rutting original surface soils and roots. In this situation, the stone may be contained by silt fence or super silt fence where adjacent to or within a TPA.
- H. All temporary RPM areas to be used beyond a single day or beyond continuous on-site supervision of the Contract Arborist shall be surrounded by temporary tree protection fence as per specifications.
- I. For temporary staging of soils beyond 24 hours "trenchless" silt fence fabric shall be installed on the lower / downhill side or as directed by the Project Arborist.
- J. If Silt Fence is required for Erosion Control in RPM areas, installation of silt fence shall be coordinated with the Contract Arborist and must be performed by the Contract Arborist to prevent damage to tree roots from trenching operations. Erosion control socks may be used in lieu of silt fabric if approved by the COTR.

5. Supersonic Air Tool (SSAT) Excavation

- A. Refer to "Hand Excavation within Tree Protection Areas" specification in this section for additional requirements.
- B. At a minimum, all SSAT work shall include the use of a barrier system such as temporary walls or tents to protect property and pedestrians from flying debris.
- C. Excavate along the edge of the proposed trench closest to the trees to be protected as shown on the plans. Roots shall be uncovered, and care taken to avoid damage to roots and bark.
- D. Excavation shall proceed per the "Hand Excavation within Tree Protection Areas" specification in this section.

6. Wood chip mulch

- A. Mulching for the duration of construction for protection and stress reduction. Mulching will increase moisture-holding capacity, minimize soil compaction, and increase needed organic composition.
- B. Mulch area options:
 - 1. For individual trees designated on the TPAK within the TPA or curvilinear TPA install mulch to a radius equal to trunk diameter inches equated to mulch ring diameter in feet (24" trunk diameter = 24' diameter mulch ring). Where planting pit areas are restricted by hardscape or other restrictions, mulch the greatest area possible.
 - 2. For linear TPAs along LOD Install mulch strips a minimum 10' wide the length of critical root zones along the outside of the LOD/ Root Prune line (just inside the Tree Protection Zone) for designated significant trees impacted by proposed construction.
 - 3. Either option may be used as appropriate for the area.
- B. For privately owned trees, any installation is contingent upon receipt of COTR's permission.

COTRs may decline.

- C. Motorized equipment shall not enter the TPA unless specifically approved by the Project Arborist and specific conditions met (RPM, AlturnaMATS, etc.). Any such motorized equipment shall be operated by a certified arborist while inside the TPA.
- D. Do not allow mulch to contact trunk/root flare.
- E. Mulch depth shall be 3" – 4".
- F. Mulch shall remain for the duration of construction and may remain permanently if the COTR approves.
- G. If the mulch is to be removed after construction, it must be removed by hand only. No equipment may be used.

7. Tree Growth Regulator (Paclobutrazol):

- A. Paclobutrazol is a compound used to regulate plant growth in such a way as to restrict canopy growth and free stored or produced energy for other uses in the tree. For highly impacted trees, more energy may be made available for fibrous root growth (to combat root loss), thicker darker leaves allowing for increased photosynthesis, and increased drought tolerance.
- B. Specific methods and dosages are contained on the label and are determined by size and species and applied by a state licensed pesticide applicator. Designated trees are shown on the TPAK.

8. Supplemental Watering

- A. This action is for high impact trees of significance during seasonal drought times of project construction. Based upon the number and size of trees various strategies can be considered to maintain adequate soil moisture during these times. These strategies may include but are not limited to the following:
 - 1. Fire hydrant connection battery powered timer and drip irrigation hose / tubing.
 - 2. Water tank truck and hand applied as directed;
 - 3. Temporary above grade poly tank with battery-powered timers for drip or soaker hoses at each TPA.
 - 4. 30-50-gallon watering cans with 6-8 drilled holes in bottom to allow slow seeping of water; spacing and rotation to reach desired gallons. Equivalent means of effectively watering trees as approved by Architect or Project Arborist
- B. Trees requiring this treatment are indicated in the TPAK. Other trees will not receive this treatment.
- C. Drought times shall be defined as:
 - 1. Periods during the growing season of two weeks or longer, where daytime high temperatures reach 80 degrees Fahrenheit or higher and less than 3/4" rainfall is recorded per week. Or,
 - 2. Periods during the growing season designated as "abnormally dry" or "drought" of any severity, by the U.S. Drought Monitor: (<http://droughtmonitor.unl.edu/>). Or,
 - 3. Any period of extraordinary circumstance, as determined by the Project Arborist or COTR.
- D. A prescription for the number of gallons and strategy for watering designated trees will be developed. Large mature trees with impacts to root systems require as much as 100- 250 gallons per week during 90-degree days during summer drought times.
- E. Periodic inspections by an ISA Certified Arborist (provided by the Contract Arborist) at this time are critical. Depth of moisture in soils shall be determined by soil sample tube or other exploratory means.
- F. Minimum watering shall be 6 applications per growing season typically July through October

with the exact timing and duration to be determined by the ISA Arborist in conjunction with the COTR. Additional unit costs per watering designated trees at prescribed rates.

9. Overhead Clearance

- A. Trees to remain shall be assessed prior to construction for overhead clearance for construction activities. Contract Arborist shall recommend either canopy pruning, temporary guying/typing of select limbs, or alternative construction methods.
- B. Pruning for clearance shall not remove branches above 12' or over 6" diameter.
- C. All pruning proposed by the Contractor and/or Contract Arborist shall first be reviewed and approved by the COTR and Project Arborist.
- D. Equipment exhaust should be directed away from trees as much as possible. Stationary equipment shall not be exhausted directly under or towards trees.
- E. The contractor shall use appropriate equipment near trees to ensure that trees are not damaged by construction. Contractor shall provide any specialized equipment needed at no additional cost to the COTR.
- F. Any pruning shall also conform to the pruning specifications in this section.

10. Soil Tests and Soil Care/Fertilization

- A. Initial soil testing within tree protection areas is required. Conduct individual soil tests for separate tree protection areas (small adjacent areas may be tested together). Soil test shall be a representative sample from each area. Soil testing shall include a texture analysis (sand, silt, and clay percentages), soluble salts, and sodium tests.
- B. Treatments to the tree protection areas for specified trees (see TPAK) shall be based on the results of the soil analysis. Fertilization should be consistent with the recommendations of the ANSI A-300 (Part 2) Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Fertilization) 2004, except as described herein.
- C. Application rates shall not exceed a rate of 1 pound of actual nitrogen per 1,000 square feet annually. Fertilizer used should include humic acids, soluble seaweed extracts and soil biological inoculants (mycorrhizae, etc.).
- D. Applications to confined areas (i.e. street tree planting pits) should be made by soil injection. In areas where adequate application rates cannot be achieved, injection should be made to the point of refusal.

11. SSAT Landscape Planting Excavation

- A. Proposed landscape planting of B&B plants within critical root zones within TPAs shall be reviewed by the Contract Arborist, contractor, and COTR in the field to determine potential for damage to priority roots of select trees and layout the limit of work.
- B. Pre-watering of the proposed areas of excavation during summer and fall months is recommended to maintain root / soil moisture.
- C. The Contract Arborist shall provide a qualified arborist crew experienced with the SSAT and landscape planting excavation to protect adjacent natural resources and construction work, open the excavation, hand prune minor roots, and identify and protect priority roots to remain. Coordination with the appropriate sub-contractor shall be made to determine appropriate width, depth, and sequencing.

3.3 FIELD QUALITY CONTROL AND MONITORING

A. Tree Condition Monitoring

- 1. An ISA Certified Arborist (provided by the Contract Arborist) shall perform monitoring twice per month year-round to monitor insects, disease, soil moisture levels, weather, and health

changes on all trees designated on Tree Protection Action Key.

2. The monitoring will include a report that details problematic areas that have been addressed, treatments provided to reduce the problem, and anticipated treatments forecast for 30 days. This report will be forwarded to the Project Arborist, Architect and COTR for documentation.
3. Any treatments recommended by the Contract Arborist not already included in the project scope shall be noted in the reports for review by the Project Arborist, Architect and COTR. No additional work is to be performed unless approved in writing by the COTR.

B. Construction Oversight by Contract Arborist

1. Any work within CRZs of retained trees shall be directly supervised by the Contract Arborist.
2. If roots are encountered during excavations, work shall progress as directed by the Contract Arborist. Contract Arborist, in coordination with the construction and design teams, shall determine appropriate means and methods to address the roots. Options may include, but not be limited to, severing the roots, hand or SSAT excavation. Contractor shall not cut roots.
3. Refer to "Hand Excavation within Tree Protection Areas" specification in this section.
4. All work shall be documented thoroughly, including photo documentation. Refer to site documentation submittal requirements.

3.4 CONTRACTOR DAMAGES AND PENALTIES

A. Remedial Measures

1. Any damage caused to the trees by the work of this contract through negligence by the contractor shall be immediately remedied by the contractor. Contractor shall be responsible for any associated costs.
2. Remedial work may include pruning, cabling, or any other measures up to and including removal and replacement, as determined by the Project Arborist and COTR.
3. Remedial work shall be performed by the Contract Arborist, as approved by the Project Arborist and COTR.
4. All required remedial work shall be performed to the satisfaction of the Project Arborist and COTR, at no additional cost to the COTR.

B. Tree Replacement

1. If damage to any tree is severe, because of negligence by the contractor as determined by the Project Arborist and COTR, it shall be replaced with a new tree of equal size caliper and species as that of the damaged tree.
2. If a replacement tree of equal size caliper is not possible as determined by the Project Arborist and COTR, it shall be replaced on an inch for inch basis with new trees of a minimum caliper size of 2-3".
3. Replacement trees shall be supplied and installed at no additional costs to the COTR, including all incidental costs including the costs of inspection of the tree at the nursery and any other incidental costs associated with tree replacement

END OF SECTION 015639

SECTION 01 5713 – TEMPORARY EROSION AND SEDIMENT CONTROL

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes requirements for temporary erosion and siltation control measures.

1.3 APPLICABLE SPECIFICATIONS

- A. DOEE Construction Standards and Specifications.
- B. DOEE Erosion and Sediment Control Manual
- C. DOEE Erosion and Sediment Control Details

1.4 INFORMATIONAL SUBMITTALS

- A. Erosion and Sedimentation Control Plan: Prior to the start of the work the Contractor shall prepare and submit a plan for applying temporary and permanent erosion and siltation control measures. The plan shall include, but is not limited to, the operations of clearing and grubbing, stripping of topsoil, grading, stabilizing cleared areas, dewatering, and the construction of structures at watercourses. Construction work shall not commence until the schedule of work, and the methods of operations have been reviewed and approved by the Engineer.
- B. Temporary measures shall be coordinated with the construction of permanent drainage facilities and other contract work to the extent practicable to ensure economical, effective, and continuous erosion and sediment control, and to prevent any damage, clogging, or other negative impacts upon the Work or other property.

1.5 PROJECT CONDITIONS

- A. Retain this article to impose responsibility for maintenance and protection of permanent services and facilities used to provide temporary service and facility. Unless otherwise specified, the Contractor is responsible for obtaining and complying with any and all applicable State, Federal, and Local permits which are required for construction.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Materials shall be at the Contractor's option with the approval of the Engineer in Accordance with DOEE.

PART 3 - EXECUTION

3.1 Installation and Maintenance of erosion and Sediment Control

- A. Contractor shall pull DOEE permits, coordinate DOEE site inspections, DOEE site approvals and pay all DOEE related fees as per jobsite site requirements.
- B. No grading operations will be allowed until temporary sediment and erosion control measures have been installed in accordance with the approved plan.
- C. Control measures shall be periodically cleaned of silt and maintained. Immediately after every rainstorm, all control measures shall be inspected and any deficiencies corrected by the Contractor.
- D. DOEE reserves the right to order the performance of other temporary measures not specifically described herein to correct an erosion or siltation condition.
- E. Temporary control measures may be removed when the area has been stabilized.

3.2 EXTENT OF GRADING OPERATIONS

- A. The Contractor shall limit the surface area of earth material exposed by grubbing, stripping of topsoil and excavation to that which is necessary to perform the next operation within a given area.
- B. Unless specifically authorized by the Engineer, the grubbing of root mat and stumps shall be confined to the area over which excavation is to be actively prosecuted within 30 days following the grubbing operations.
- C. The stripping of topsoil shall be confined to the area over which excavation is to be actively prosecuted within 7 days following the stripping operations; and excavation and embankment construction shall be confined to the minimum area necessary to accommodate the Contractor's equipment and work force engaged in the earth moving work.
- D. No disturbed area, is to remain denuded longer than 7 days without temporary seeding or otherwise stabilizing the area.

3.3 DEWATERING AND DISCHARGES

- A. All dewatering operations shall be conducted in a manner that prevents or minimizes the amount of sediment or other pollutants which discharge to the storm sewer system, which includes curb and gutter, or any open watercourse. Any discharge from dewatering operations shall be properly filtered prior to being discharged. Dewatering activities shall not create any erosion nor flooding. A dewatering plan must be included as part of the Erosion and Sediment Control plan with sufficient detail to ensure that the proposed dewatering will meet all applicable requirements.
- B. All non-stormwater discharges to the DC Water's storm sewer system, which includes curb and gutter, or any open watercourse must comply regulations. Contaminants, including but not limited to, volatile organic compounds, petroleum products, metals, PCBs/Pesticides, shall not be discharged to the DC Waters storm sewer system without approval from DC Water.
- C. Contractors shall not dump or dispose of anything in a storm drain, street, stream, or riparian area that could cause adverse conditions. Contractors shall employ good housekeeping and pollution prevention measures at work sites at all times. Work areas, including staging or stockpile areas, shall be kept clean and free of trash and debris to the maximum extent possible. Construction materials shall be properly stored and secured. Stockpiled materials shall be kept covered and

perimeter controls shall be employed to minimize exposure to wind, precipitation, and runoff. Equipment and vehicle washing shall not be permitted onsite without proper controls and facilities to collect all sediment and/or pollutants. Spill kits and appropriate tools for cleanup shall be kept on-site at all times. Spills shall be cleaned immediately using absorbent materials or other appropriate measures which will prevent any pollutants from entering a storm drain or open watercourse.

END OF SECTION 01 5713

FOR REFERENCE ONLY

SECTION 01 5715 - TEMPORARY NOISE AND VIBRATION CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes requirements for temporary acoustic walls and associated structures.

1.2 REFERENCES

- A. "The Smithsonian National Zoo – Arabian Leopard Enclosure: Preliminary Acoustic Narrative" Metropolitan Acoustics, January 22, 2026

1.3 SUBMITTALS

- A. Implementation and Termination Schedule: Within 15 days of date established for commencement of the Work, submit schedule indicating implementation and termination dates of each temporary measures as described in this section.
- B. Site Plan: Show temporary facilities, utility hookups, staging areas, and parking areas for construction personnel integrated with temporary noise barrier indicated on the site plan.
- C. Noise and Vibration Control Plan: Identify construction activities that may impact the occupancy and use of existing spaces within the project site or adjacent existing buildings, whether occupied by others, or occupied by the Owner. Include the following:
 - 1. Methods used to meet the goals and requirements of the Owner.
 - 2. Concrete cutting method(s) to be used.
 - 3. Location of construction devices on the site.
 - 4. Show compliance with the use and maintenance of quieted construction devices for the duration of the Project.
 - 5. Indicate activities that may disturb adjacent building occupants and that are planned to be performed during non-standard working hours as coordinated with the Owner.
 - 6. Indicate locations of sensitive areas or other areas requiring special attention as identified by Owner. Indicate means for complying with Owner's requirements.
- D. Product Data: Provide product data sheet clearly indication height, color, and composition of acoustic canvas panels. Structure from which panels will be hung to also be provided.
- E. Warranty Documentation
- F. Shop Drawings:
 - 1. Clearly indicate layout of individual panels integrated on the site coordinated and located on a site plan.
 - 2. Engineer sealed drawings of structural system from which acoustic canvas panels to be hung to be provided showing typical elevation, member sizes, plan, etc.

1.4 MOCKUPS

- A. Pre-installation Meeting: Pre-installation meeting to take place with Owner and Architect prior to installation of in-place mockup.
- B. In-place Mockup: Provide on-site mockup of no less than (2) panels in place on site.

1.5 PROJECT CONDITIONS

- A. Temporary Use of Permanent Facilities: Engage Installer of each permanent service to assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Acoustic Canvas Panels (Temporary Noise Barrier Fence):
 - 1. Manufacturers:
 - a. SoftdB (Basis of Design)
 - b. Environmental Noise Control Sound Walls
 - c. Noise Monitoring Services Temporary Sound Walls
 - 2. Material: PVC fabric, ultrasonic welded, reinforced with fiberglass, encasing 50mm Rockwool acoustic insulation and high-density noise reduction vinyl sheet.
 - a. UV resistant and watertight.
 - 3. Sound Attenuation: minimum STC-34
 - 4. Warranty: Minimum 1-year
 - 5. Face Weight: Minimum 4 PSF
 - 6. Height: 15 Feet
 - 7. Length: 160 feet (see Preliminary Acoustic Narrative for additional information)
 - 8. Support Structure: As specified by Contractor/Manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.
 - 1. Locate facilities to limit site disturbance as specified in Section 01 1000 "Summary."
- B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

3.2 SECURITY AND PROTECTION FACILITIES INSTALLATION

- A. Site Enclosure Fence and Temporary Noise Barrier: Before construction operations begin, furnish and install site enclosure fence in a manner that will prevent people from easily entering site except by entrance gates.

1. Extent of Fence: As required to enclose entire Project site or portion determined sufficient to accommodate construction operations.

3.3 OPERATION, TERMINATION, AND REMOVAL

- A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.
- B. Maintenance: Maintain facilities in good operating condition until removal.
 1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.
- C. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.
 1. Materials and facilities that constitute temporary facilities are property of Contractor. Owner reserves right to take possession of Project identification signs.
 2. At Substantial Completion, repair, renovate, and clean permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 01 7700 "Closeout Procedures."

END OF SECTION

SECTION 01 6000 - PRODUCT REQUIREMENTS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.
- B. Related Requirements:
 - 1. Division 01 Section 013300 "Submittal Procedures."
 - 2. Division 01 Section 014200 "References" for applicable industry standards for products specified.
 - 3. Division 01 Section 017700 "Closeout Procedures" for submitting warranties for contract closeout.

1.3 DEFINITIONS

- A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.
 - 1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature that is current as of date of the Contract Documents.
 - 2. New Products: Items that have not previously been incorporated into another project or facility. Products salvaged or recycled from other projects are not considered new products.
 - 3. Comparable Product: Product that is demonstrated and approved through submittal process to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.
- B. Basis-of-Design Product Specification: A specification in which a specific manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation, to establish the significant qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics for purposes of evaluating comparable products of additional manufacturers named in the specification.
- C. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Construction Documents and proposed by Contractor.
- D. Manufacturer's Warranty: Preprinted written warranty published by individual manufacturer for a particular product and specifically endorsed by manufacturer to Owner.
- E. Special Warranty: Written warranty required by or incorporated into the Construction Documents, either to extend time limit provided by manufacturer's warranty or to provide more

rights for Owner.

1.4 SUBMITTALS

- A. Product List: Submit a list, in tabular form, showing specified products. Include generic names of products required. Include manufacturer's name and proprietary product names for each product.
1. Coordinate product list with Contractor's Construction Schedule and the Submittals Schedule.
 2. Form: Tabulate information for each product under the following column headings:
 - A. Specification Section number and title.
 - B. Generic name used in the Construction Documents.
 - C. Proprietary name, model number, and similar designations.
 - D. Manufacturer's name and address.
 - E. Supplier's name and address.
 - F. Installer's name and address.
 - G. Projected delivery date or time span of delivery period.
 - H. Identification of items that require early submittal approval for scheduled delivery date.
 3. Completed List: Within 60 days after date of commencement of the Work, submit 5 copies of completed product list. Include a written explanation for omissions of data and for variations from Construction requirements.
 4. COTR's Action: COTR will respond in writing to Contractor within 21 days of receipt of completed product list. COTR's response will include a list of unacceptable product selections and a brief explanation of reasons for this action. COTR's response, or lack of response, does not constitute a waiver of requirement that products comply with the Construction Documents.
- B. Substitution Requests: Substitutions may be considered only in accordance with the procedures indicated in the "Brand Name or Equal" Contract Clause. Submit three copies of each request for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.
1. Substitution Request Form: Submit request on Supplier/Subcontractor letterhead, accompanied by cover letter on General Contractor's letterhead.
 2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:
 - A. Statement indicating why specified material or product cannot be provided.
 - B. Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
 - C. Detailed comparison of significant qualities of proposed substitution with those of the work specified. Significant qualities may include attributes such as performance, weight, size, durability, visual effect, and specific features and requirements indicated.
 - D. Product Data, including drawings and descriptions of products and fabrication and installation procedures.
 - E. Samples, where applicable or requested.
 - F. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners.
 - G. Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
 - H. Research/evaluation reports evidencing compliance with building code in effect for Project, from a model code organization acceptable to authorities having jurisdiction.

- I. Detailed comparison of Contractor's Construction Schedule using proposed substitution with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating lack of availability or delays in delivery.
 - J. Cost information, including a proposal of change, if any, in the Contract Sum.
 - K. Contractor's certification that proposed substitution complies with requirements in the Construction Documents and is appropriate for applications indicated.
 - L. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.
 - M. Any additional costs incurred by SI (e.g., travel, site visit, AE investigation, etc.) related to the substitution shall be borne by the Contractor.
3. COTR's Action: If necessary, COTR will request additional information or documentation for evaluation within one week of receipt of a request for substitution. COTR will notify Contractor of acceptance or rejection of proposed substitution within 21 days of receipt of request, or 15 days of receipt of additional information or documentation, whichever is later.
- a. Form of Acceptance: Letter from COTR and/or Change Order/Contract Modification, if necessary.
 - b. Use product specified if COTR cannot make a decision on use of a proposed substitution within time allocated.
 - c. Substitution request should not result in basis for Contract Time extension.
- C. Basis-of-Design Product Specification Submittal: Comply with requirements in Division 01 Section "Submittal Procedures." Show compliance with requirements.

1.5 QUALITY ASSURANCE

- A. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options.
 - 1. Each contractor is responsible for providing products and construction methods compatible with products and construction methods of other contractors.
 - 2. If a dispute arises between contractors over concurrently selectable but incompatible products, Architect will determine which products shall be used.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.
- B. Delivery and Handling:
 - 1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.
 - 2. Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
 - 3. Deliver products to Project site in an undamaged condition in manufacturer's original

sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.

4. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

C. Storage:

1. Store products to allow for inspection and measurement of quantity or counting of units.
2. Store materials in a manner that will not endanger Project structure.
3. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
4. Protect foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
5. Comply with product manufacturer's written instructions for temperature, humidity, Ventilation, and weather-protection requirements for storage.
6. Protect stored products from damage and liquids from freezing.
7. Provide a secure location and enclosure at Project site for storage of materials and equipment by Owner's construction forces. Coordinate location with Owner.

1.7 PRODUCT WARRANTIES

- A. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturers' disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.
 1. Manufacturer's Warranty: Written warranty furnished by individual manufacturer for a particular product and specifically endorsed by manufacturer to Owner.
 2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for Owner.
- B. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution.
 1. Manufacturer's Standard Form: Modified to include Project specific information and properly executed.
 2. Specified Form: When specified forms are included with the Specifications, prepare a written document using indicated form properly executed.
 3. See other Sections for specific content requirements and particular requirements for submitting special warranties.
- C. Submittal Time: Comply with requirements in Section 017700 "Closeout Procedures."

PART 2 - PRODUCTS

2.1 PRODUCT SELECTION PROCEDURES

- A. General Product Requirements: Provide products that comply with the Contract Documents, are undamaged and, unless otherwise indicated, are new at time of installation.
 1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.
 2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.

3. COTR reserves the right to limit selection to products with warranties not in conflict with requirements of the Contract Documents.
 4. Where products are accompanied by the term "as selected," COTR will make selection.
 5. Where products are accompanied by the term "match sample," sample to be matched is provided by the COTR.
 6. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.
 7. Or Equal: For products specified by name and accompanied by the term "or equal," or "or approved equal," or "or approved," comply with requirements in "Comparable Products" Article to obtain approval for use of an unnamed product.
- B. Product Selection Procedures:
1. Product: Where Specification paragraphs or subparagraphs titled "Product" name a single product and manufacturer, provide the product named.
 - a. Substitutions may be considered as provided in "Brand Name or Equal" Clause.
 - b. Contractor shall provide all additional labor and materials consequential to the approval of any substitution or component thereof.
 2. Manufacturer/Source: Where Specification paragraphs or subparagraphs titled "Manufacturer" or "Source" name single manufacturers or sources, provide a product by the manufacturer or from the source named that complies with requirements. Substitutions may be considered only as provided in the "Brand Name or Equal" Clause.
 3. Products: Where Specification paragraphs or subparagraphs titled "Products" introduce a list of names of both products and manufacturers, provide one of the products listed that complies with requirements. Substitutions may be considered only as provided in the "Brand Name or Equal" Clause.
 4. Manufacturers: Where Specification paragraphs or subparagraphs titled "Manufacturers" introduce a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Substitutions may be considered only as provided in the "Brand Name or Equal" Clause.
 5. Available Products: Where Specification paragraphs or subparagraphs titled "Available Products" introduce a list of names of both products and manufacturers, provide one of the products listed or another product that complies with requirements. Comply with provisions in "Comparable Products" Article ("Brand Name or Equal" Clause) to obtain approval for use of an unnamed product.
 6. Available Manufacturers: Where Specification paragraphs or subparagraphs titled "Available Manufacturers" introduce a list of manufacturers' names, provide a product by one of the manufacturers listed or another manufacturer that complies with requirements. Comply with provisions in "Comparable Products" Article ("Brand Name or Equal" Clause) to obtain approval for use of an unnamed product.
 7. Product Options: Where Specification paragraphs titled "Product Options" indicate that size, profiles, and dimensional requirements on Drawings are based on a specific product or system, provide either the specific product or system indicated or a comparable product or system by another manufacturer. Comply with provisions in "Product Substitutions" Article ("Brand Name or Equal" Clause).
 8. Basis-of-Design Products: Where Specification paragraphs or subparagraphs titled "Basis-of-Design Products" are included and also introduce or refer to a list of manufacturers' names, provide either the specified product or a comparable product by one of the other named manufacturers. Drawings and Specifications indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with provisions in "Comparable Products" Article ("Brand Name or Equal" Clause) to obtain approval for use of an unnamed product.
 9. Visual Matching Specification: Where Specifications require matching an established Sample, select a product (and manufacturer) that complies with requirements and matches sample. COTR's decision will be final on whether a proposed product matches satisfactorily.

- a. If no product available within specified category matches satisfactorily and complies with other specified requirements, comply with provisions of the Contract Documents on "substitutions" for selection of a matching product.
- 10. Visual Selection Specification: Where Specifications include the phrase "as selected from manufacturer's colors, patterns, textures or a similar phrase, select a product (and manufacturer) that complies with other specified requirements.
 - a. Standard Range: Where Specifications include the phrase "standard range of colors, patterns, textures" or similar phrase, COTR will select color, pattern, or texture from manufacturer's product line that does not include premium items.
 - b. Full Range: Where Specifications include the phrase "full range of colors, patterns, textures" or similar phrase, COTR will select color, pattern, or texture from

manufacturer's product line that includes both standard and premium items.

- 11. Codes, Standards, and Regulations: Select products that are in compliance with the Project specifications and SI standards, as well as with construction standards and all applicable codes and regulations.
- 12. Performance Requirements: Provide products that comply with specific performances indicated and are recommended by the manufacturer (in published product literature or by individual certification) for the application indicated.
- 13. Prescriptive Requirements: Provide products that have been produced in accordance with prescriptive requirements, using specified ingredients and components, and comply with specified requirements for mixing, fabricating, curing, finishing, testing, and other operations in the manufacturing process.

2.2 PRODUCT SUBSTITUTIONS

- A. Timing: COTR will consider requests for substitution. Substitutions may be considered only in accordance with the procedures indicated in the "Brand Name or Equal" Contract Clause.
- B. Conditions: COTR will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, COTR will return requests without action, except to record noncompliance with these requirements:
 - 1. Requested substitution offers SI a substantial advantage in cost, time, energy conservation, or other considerations, after deducting additional responsibilities SI must assume.
 - 2. Requested substitution is consistent with the Construction Documents and will produce indicated results.
 - 3. Substitution request is fully documented and properly submitted.
 - 4. Requested substitution will not adversely affect Contractor's Construction Schedule.
 - 5. Requested substitution has received necessary approvals of authorities having jurisdiction.
 - 6. Requested substitution is compatible with other portions of the Work.
 - 7. Requested substitution has been coordinated with other portions of the Work.
 - 8. Requested substitution provides specified warranty.
 - 9. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

2.3 COMPARABLE PRODUCTS

- A. "Brand Name or Equal" Clause governs. Where products or manufacturers are specified by name, submit the following, in addition to other required submittals, to obtain approval of an unnamed product:

1. Evidence that the proposed product does not require revisions to the Construction Documents that it is consistent with the Construction Documents and will produce the indicated results, and that it is compatible with other portions of the Work.
2. Detailed comparison of significant qualities of proposed product with those named in the Specifications or commonly referenced in the industry. Significant qualities include, but are not limited to, attributes such as performance, weight, size, durability, material construction, maintainability, sustainability, compatibility, aesthetic and visual effect, texture, toxicity, consequential effects of use, and specific features and requirements indicated.
3. Evidence that proposed product provides specified warranty.
4. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners.

PART 3 - EXECUTION (Not

Used)

END OF SECTION 016000

SECTION 01 7300 - EXECUTION REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general administrative and procedural requirements governing execution of the Work including, but not limited to, the following:
 - 1. Construction layout.
 - 2. Field engineering and surveying.
 - 3. Installation of the Work.
 - 4. Cutting and patching.
 - 5. Coordination of Owner-installed products.
 - 6. Progress cleaning.
 - 7. Starting and adjusting.
 - 8. Protection of installed construction.
 - 9. Correction of the Work.
- B. Related Requirements:
 - 1. Division 01 Section 013100 "Project Management and Coordination" for procedures for coordinating field engineering with other construction activities.
 - 2. Division 01 Section 013300 "Submittal Procedures" for submitting surveys.
 - 3. Division 01 Section 017700 "Closeout Procedures" for submitting final property survey with Project Record Documents, recording of SI-accepted deviations from indicated lines and levels, and final cleaning.

1.3 DEFINITIONS

- A. Cutting: Removal of in-place construction necessary to permit installation or performance of other work.
- B. Patching: Fitting and repair work required to restore construction to original conditions after installation of other work.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For land surveyor and professional engineer.
- B. Certificates: Submit certificate signed by professional engineer certifying that location and elevation of improvements comply with requirements.
- C. Cutting and Patching Plan: Submit plan describing procedures at least 10 days prior to the time cutting and patching will be performed. Include the following information:
 - 1. Extent: Describe reason for and extent of each occurrence of cutting and patching.
 - 2. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building appearance

- and other significant visual elements.
 - 3. Products: List products to be used for patching and firms or entities that will perform patching work.
 - 4. Dates: Indicate when cutting and patching will be performed.
 - 5. Utilities and Mechanical and Electrical Systems: List services and systems that cutting and patching procedures will disturb or affect. List services and systems that will be relocated and those that will be temporarily out of service. Indicate length of time permanent services and systems will be disrupted.
 - a. Include description of provisions for temporary services and systems during interruption of permanent services and systems.
 - D. Landfill Receipts: Submit copy of receipts issued by a landfill facility, licensed to accept hazardous materials, for hazardous waste disposal.
 - E. Certified Surveys: Submit one hard, CAD / GIS, and PDF copies signed by professional engineer.
 - F. Final Site Survey: Submit one hard, CAD / GIS, and PDF copies showing the Work performed and record survey data.
- 1.5 QUALITY ASSURANCE
- A. Land Surveyor Qualifications: A professional land surveyor who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing land-surveying services of the kind indicated.
 - B. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.
 - 1. Structural Elements: When cutting and patching structural elements, notify C O T R of locations and details of cutting and await directions from COTR before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.
 - 2. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety. Operational elements include the following:
 - a. Primary operational systems and equipment.
 - b. Fire separation assemblies.
 - c. Air or smoke barriers.
 - d. Fire-suppression systems.
 - e. Mechanical systems piping and ducts.
 - f. Control systems.
 - g. Communication systems.
 - h. Fire-detection and -alarm systems
 - i. Electrical wiring systems.
 - j. Operating systems of special construction.
 - 3. Other Construction Elements: Do not cut and patch other construction elements or components in a manner that could change their load-carrying capacity, which results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety.

Other construction elements include but are not limited to the following:

- a. Water, moisture, or vapor barriers.
 - b. Membranes and flashings.
 - c. Exterior curtain-wall construction.
 - d. Sprayed fire-resistive material.
 - e. Equipment supports.
 - f. Piping, ductwork, vessels, and equipment.
 - g. Noise- and vibration-control elements and systems.
4. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
- C. Cutting and Patching Conference: Before proceeding, meet at Project site with parties involved in cutting and patching, including mechanical and electrical trades. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.
- D. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of products and equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Comply with requirements specified in other Sections.
- 1. For projects requiring compliance with sustainable design and construction practices and procedures, use products for patching that comply with requirements in Section 018113.13 "Sustainable Design Requirements - LEED for New Construction and Major Renovations."
- B. In-Place Materials: Use materials for patching identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
- 1. If identical materials are unavailable or cannot be used, use materials that, when installed, will provide a match acceptable to Architect for the visual and functional performance of in-place materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.
- 1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping, underground electrical services, and other utilities.
 - 2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

- B. Existing Utilities: The existence and location of underground and other utilities and

construction indicated as existing are not guaranteed. Before beginning site work, investigate and verify the existence and location of underground utilities and other construction affecting the Work.

1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping, and underground electrical services.
 2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.
- C. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.
1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
 2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.
 3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
- D. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:
1. Description of the Work.
 2. List of detrimental conditions, including substrates.
 3. List of unacceptable installation tolerances.
 4. Recommended corrections.
- E. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Existing Utility Information: Furnish information to COTR that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.
- B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by SI or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
1. Notify COTR not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without COTR's written permission.
- C. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
- D. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents caused by differing field conditions outside the control of Contractor, submit a request for information to Architect according to requirements in Section 013100 "Project Management and Coordination."

3.3 CONSTRUCTION LAYOUT

- A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify COTR promptly.
- B. General: Engage a professional engineer to lay out the Work using accepted surveying practices.
 - 1. Establish benchmarks and control points to set lines and levels at each story of construction and elsewhere as needed to locate each element of Project.
 - 2. Establish limits on use of Project site.
 - 3. Establish dimensions within tolerances indicated. Do not scale Drawings to obtain required dimensions.
 - 4. Inform installers of lines and levels to which they must comply.
 - 5. Check the location, level and plumb, of every major element as the Work progresses.
 - 6. Notify COTR when deviations from required lines and levels exceed allowable tolerances.
 - 7. Close site surveys with an error of closure equal to or less than the standard established by authorities having jurisdiction.
- C. Site Improvements: Locate and layout site improvements, including pavements, grading, fill and topsoil placement, utility slopes, and rim and invert elevations.
- D. Building Lines and Levels: Locate and lay out control lines and levels for structures, building foundations, column grids, and floor levels, including those required for mechanical and electrical work. Transfer survey markings and elevations for use with control lines and levels. Level foundations and piers from two or more locations.
- E. Record Log: Maintain a log of layout control work. Record deviations from required lines and levels. Include beginning and ending dates and times of surveys, weather conditions, name and duty of each survey party member, and types of instruments and tapes used. Make the log available for reference by COTR.

3.4 FIELD ENGINEERING

- A. Identification: COTR will identify existing benchmarks, control points, and property corners.
- B. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.
 - 1. Do not change or relocate existing benchmarks or control points without prior written approval COTR. Report lost or destroyed permanent benchmarks or control points promptly. Report the need to relocate permanent benchmarks or control points to COTR before proceeding.
 - 2. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.
- C. Benchmarks: Establish and maintain a minimum of two permanent benchmarks on Project site, referenced to data established by survey control points. Comply with authorities having jurisdiction for type and size of benchmark.
 - 1. Record benchmark locations, with horizontal and vertical data, on Project Record Documents.
 - 2. Where the actual location or elevation of layout points cannot be marked, provide temporary reference points sufficient to locate the Work.

3. Remove temporary reference points when no longer needed. Restore marked construction to its original condition.
- D. Certified Survey: On completion of foundation walls, major site improvements, and other work requiring field-engineering services, prepare a certified survey showing dimensions, locations, angles, and elevations of construction and sitework.
- E. Final Property Survey: Engage a professional engineer to prepare a final property survey showing significant features (real property) for the Project. Include a certification on the survey, signed by a professional engineer, that certifies the metes, bounds, lines, and levels are accurately positioned as shown on the survey.
 1. Show boundary lines, monuments, streets, site improvements and utilities, existing improvements, and significant vegetation, adjoining properties, acreage, grade contours, and the distance and bearing from a site corner to a legal point.
 2. Recording: At Substantial Completion, have the final property survey recorded by or with authorities having jurisdiction as the official "property survey."

3.5 INSTALLATION

- A. General: Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.
 1. Make vertical work plumb and make horizontal work level.
 2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
 3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
 4. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces.
- B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.
- C. Install products at the time and under conditions that will ensure the best possible results. Maintain conditions required for product performance until Substantial Completion.
- D. Conduct construction operations so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy.
- E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on site and placement in permanent locations.
- F. Tools and Equipment: Do not use tools or equipment that produce harmful noise levels.
- G. Templates: Obtain and distribute templates, to the party's involved, for work specified to be factory prepared and field installed. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.
- H. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the work. Where size and type of attachments are not indicated, verify size and type required for load conditions.
 1. Mounting Heights: Where mounting heights are not indicated, mount components at

- heights directed by COTR.
- 2. Allow for building movement, including thermal expansion and contraction.
- 3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, which are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.
- I. Joints: Make joints of uniform width. Where joint locations in exposed work are not indicated, arrange joints for the best visual effect. Fit exposed connections together to form hairline joints.
- J. Hazardous Materials: Use products, cleaners, and installation materials that are not considered hazardous.

3.6 CUTTING AND PATCHING

- A. Cutting and Patching, General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
 - 1. Cut in-place construction to provide for installation of other components or performance of other construction and subsequently patch as required to restore surfaces to their original condition.
- B. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during installation or cutting and patching operations, by methods and with materials that won't void existing warranties.
- C. Temporary Support: Provide temporary support of work to be cut.
- D. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.
- E. Adjacent Occupied Areas: Where interference with use of adjoining areas or interruption of free passage to adjoining areas is unavoidable, coordinate cutting and patching according to requirements in Section 011000 "Summary."
- F. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to prevent interruption to occupied areas.
- G. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
 - 1. In general, use hand or small power tools designed for sawing and grinding, not hammering, and chopping. Cut holes and slots neatly to minimum size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
 - 2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
 - 3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond- core drill.
 - 4. Excavating and Backfilling: Comply with requirements in applicable Sections where required by cutting and patching operations.
 - 5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portions of pipe or conduit to

- prevent entrance of moisture or other foreign matter after cutting.
 - 6. Proceed with patching after construction operations requiring cutting are complete.
- H. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other work. Patch with durable seams that are as invisible as practicable. Provide materials and comply with installation requirements specified in other Sections, where applicable.
 - 1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate physical integrity of installation.
 - 2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will minimize evidence of patching and refinishing.
 - a. Clean piping, conduit, and similar features before applying paint or other finishing materials.
 - b. Restore damaged pipe covering to its original condition.
 - 3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
 - a. Where patching occurs in a painted surface, prepare substrate, apply primer, and intermediate paint coats appropriate for substrate over the patch, and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.
 - 4. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
 - 5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition and ensures thermal and moisture integrity of building enclosure.
- I. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

3.7 SUBMITTALS

- A. Cutting and Patching Proposal: For areas not indicated to be cut and patched in the Construction Drawings, submit a proposal describing procedures at least 10 days before the time cutting and patching will be performed, requesting approval to proceed. Include the following information:
 - 1. Extent: Describe cutting and patching, show how they will be performed, and indicate why they cannot be avoided.
 - 2. Changes to Existing Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building's appearance and other significant visual elements.
 - 3. Products: List products to be used and firms or entities that will perform the Work.
 - 4. Dates: Indicate when cutting and patching will be performed.
 - 5. Utilities: List utilities that cutting and patching procedures will disturb or affect. List utilities that will be relocated and those that will be temporarily out of service. Indicate how long service will be disrupted.

6. Structural Elements: Where cutting and patching involve adding reinforcement to structural elements, submit details and engineering calculations showing integration of reinforcement with original structure. Do not cut or alter structural members except where noted on the drawings, without approval of
7. the cutting and patching proposal and authorization of the COTR. COTR's Approval: Obtain approval of cutting and patching proposal before cutting and patching. Approval does not waive right to later require removal and replacement of unsatisfactory work.
8. Torch or Arc cutting, burning, welding and penetrations through fire separations must be coordinated with the COTR and submitted for prior approvals and permits.

3.8 QUALITY ASSURANCE

- A. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio.
- B. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that result in increased maintenance or decreased operational life or safety.
- C. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in COTR's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
- D. Call unknown conditions exposed by removal of existing work that do not match new finishes or align with new work to the COTR's immediate attention. Necessary corrective work directed by the COTR will be subject to adjustment provisions as stated in the Contract.

3.9 WARRANTY

- A. Existing Warranties: Remove, replace, patch, and repair materials and surfaces cut or damaged during cutting and patching operations, by methods and with materials so as not to void existing warranties.

END OF SECTION 017300

SECTION 01 7419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

- A. Reduce construction and demolition waste on job site and minimize waste sent to landfills through implementation of Construction Waste Management Plan as required by USGBC's LEED® 2009 for New Construction & Major Renovations and as outlined within this Section and in the Sections referenced herein
- B. Section includes administrative and procedural requirements for the following:
 - 1. Salvaging nonhazardous waste.
 - 2. Recycling nonhazardous waste.
 - 3. Disposing of nonhazardous waste.
- C. Related Requirements:
 - 1. Section 024119 "Selective Demolition" for disposition of waste resulting from partial demolition of buildings, structures, and site improvements.
 - 2. Section 042000 "Unit Masonry" for disposal requirements for masonry waste.
 - 3. Section 311000 "Site Clearing" for disposition of waste resulting from site clearing and removal of above - and below-grade improvements.

1.3 DEFINITIONS

- A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.
- B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.
- C. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.
- A. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.
- E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.
- F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

1.4 PERFORMANCE REQUIREMENTS

- A. General: Achieve end-of-Project rates for salvage/recycling as required for percent by weight of total non-hazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials **including the following**:
 - 1. Demolition Waste:
 - a. Asphalt paving.

- b. Concrete.
- c. Concrete reinforcing steel.
- d. Brick.
- e. Concrete masonry units.
- f. Wood studs.
- g. Wood joists.
- h. Plywood and oriented strand board.
- i. Wood paneling.
- j. Wood trim.
- k. Structural and miscellaneous steel.
- l. Rough hardware.
- m. Roofing.
- n. Insulation.
- o. Doors and frames.
- p. Door hardware.
- q. Windows.
- r. Glazing.
- s. Metal studs.
- t. Gypsum board.
- u. Acoustical tile and panels.
- v. Carpet.
- w. Carpet pad.
- x. Demountable partitions.
- y. Equipment.
- z. Cabinets.
- aa. Plumbing fixtures.
- bb. Piping.
- cc. Supports and hangers. D
- d. Valves.
- ee. Sprinklers.
- ff. Mechanical equipment.
- gg. Refrigerants.
- hh. Electrical conduit.
- ii. Copper wiring.
- jj. Lighting fixtures.
- kk. Lamps.
- ll. Ballasts.
- mm. Electrical devices.
- nn. Switchgear and panelboards.
- oo. Transformers.
- 2. Construction Waste:
 - a. Masonry and CMU.
 - b. Lumber.
 - c. Wood sheet materials.
 - d. Wood trim.
 - e. Metals.
 - f. Roofing.
 - g. Insulation.
 - h. Carpet and pad.
 - i. Gypsum board.
 - j. Piping.
 - k. Electrical conduit.
 - l. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following

uncontaminated packaging materials:

- 1) Paper.
- 2) Cardboard.
- 3) Boxes.
- 4) Plastic sheet and film.
- 5) Polystyrene packaging.
- 6) Wood crates.
- 7) Plastic pails.

1.1 ACTION SUBMITTALS

- A. Waste Management Plan: Submit plan within 7 days of date established for **commencement of the Work**.
- B. Prior to any waste removal and within 30 days of Contract award, submit for approval a detailed Construction and Demolition Waste Management Plan outlined in this Section:
 1. Analysis of estimated job-site waste to be generated, including types and quantities of compostable, recyclable and salvageable materials.
 2. Description of means and methods to achieve 75 percent diversion requirement for compostable, recyclable, and salvageable materials, including those that may be donated to charitable organizations.
 3. Identification of recycling contractors and haulers proposed for use in the project and locations accepting construction waste materials or entities providing related services.

1.2 INFORMATIONAL SUBMITTALS

- A. Waste Reduction Progress Reports: Concurrent with each Application for Payment, submit report. Include the following information:
 1. Material category.
 2. Generation points of waste.
 3. Total quantity of waste in tons.
 4. Quantity of waste salvaged, both estimated and actual in tons.
 5. Quantity of waste recycled, both estimated and actual in tons.
 6. Total quantity of waste recovered (salvaged plus recycled) in tons.
 7. Total quantity of waste recovered (salvaged plus recycled) as a percentage of total waste.
- B. Waste Reduction Calculations: Before request for Substantial Completion, submit calculated end-of-Project rates for salvage, recycling, and disposal as a percentage of total waste generated by the Work.
- C. Records of Donations: Indicate receipt and acceptance of salvageable waste donated to individuals and organizations. Indicate whether organization is tax exempt.
- D. Records of Sales: Indicate receipt and acceptance of salvageable waste sold to individuals and organizations. Indicate whether organization is tax exempt.
- E. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.
- F. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and

invoices.

- G. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

1.3 QUALITY ASSURANCE

- A. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.
- B. Regulatory Requirements: Comply with hauling and disposal regulations of authorities having jurisdiction.
- C. Waste Management Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to waste management including, but not limited to, the following:
 - a. Review requirements for documenting quantities of each type of waste and its disposition.
 - b. Review and finalize procedures for materials separation and verify availability of containers and bins needed to avoid delays.
 - c. Review procedures for periodic waste collection and transportation to recycling and disposal facilities.
 - d. Review waste management requirements for each trade.

1.4 WASTE MANAGEMENT PLAN

- A. General: Develop a waste management plan according to ASTM E 1609 and requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. **Distinguish between demolition and construction waste.** Indicate quantities by weight or volume but use same units of measure throughout waste management plan.
- B. Waste Identification: Indicate anticipated types and quantities of **demolition, site-clearing and construction** waste generated by the Work. Use **Form CWM-1 for construction waste and Form CWM- 2 for demolition waste**. Include estimated quantities and assumptions for estimates.
- C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Use **Form CWM-3 for construction waste and Form CWM-4 for demolition waste**. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.
 - 1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
 - 2. Salvaged Materials for Sale: For materials that will be sold to individuals and organizations, include list of their names, addresses, and telephone numbers.
 - 3. Salvaged Materials for Donation: For materials that will be donated to individuals and organizations, include list of their names, addresses, and telephone numbers.
 - 4. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
 - 5. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
 - 6. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.

- D. Cost/Revenue Analysis: Indicate total cost of waste disposal as if there was no waste management plan and net additional cost or net savings resulting from implementing waste management plan. Use Form **CWM- 5 for construction waste** and Form **CWM-6 for demolition waste**. Include the following:
1. Total quantity of waste.
 2. Estimated cost of disposal (cost per unit). Include hauling and tipping fees and cost of collection containers for each type of waste.
 3. Total cost of disposal (with no waste management).
 4. Revenue from salvaged materials.
 5. Revenue from recycled materials.
 6. Savings in hauling and tipping fees by donating materials.
 7. Savings in hauling and tipping fees that are avoided.
 8. Handling and transportation costs. Include cost of collection containers for each type of waste.
 9. Net additional cost or net savings from waste management plan.
- E. Training and Coordination:
1. Furnish copies of approved Waste Management Plan to all on-site supervisors, each subcontractor, Owner, and Architect.
 2. Instruction: Provide on-site instruction of appropriate separation, handling, and recycling, salvage, reuse, and return methods to be used by all entities at the appropriate stages of the Project.
 3. Meetings: Include construction waste management on the agenda of all required regularly scheduled construction meetings.
- F. Facilities: Provide designated facilities for co-mingling or separation and storage of materials for recycling, salvage, reuse, return, and waste disposal, per approved Construction Waste Management Plan for use by all contractors and installers.
1. Provide bi-lingual signage.
 2. Provide materials for barriers and enclosures that are nonhazardous, recyclable, or reusable to the maximum extent possible; reuse project construction waste materials if possible.
 3. Provide adequate space, convenient to subcontractors, for pick-up and delivery.
 4. Keep recycling and waste bin areas neat and clean to avoid contamination of materials.
- G. Records: Maintain onsite logs for each load of materials removed from site:
1. Landfill Log: Include type of material, load (by weight or volume), recycling/hauling service, date accepted by landfill, and facility fee.
 2. Waste Diversion: Include type of material, load (by weight or volume), recycling/hauling service, date accepted by recycling service, or non-profit receiver and facility fee.
 3. Where comingling occurs prior to collection, track the amount of construction waste diverted from landfill based on the weight or volume of the removed co-mingled waste and provide the documentation of percentages of recycled from the sorting facility.
- H. Methods of waste disposal that are not acceptable for Sustainable Design Requirements are:
1. Burning or incinerating on or off project site.
 2. Burying on project site, other than fill.
 3. Dumping or burying on other property, public or private, other than official landfill.
 4. Illegal dumping or burying.
- I. Recycling Procedures:

1. Co-mingle or separate, store, protect, and handle at the site identified recyclable waste products in order to prevent contamination of materials and to maximize recyclability of identified materials. Arrange for timely pickups from the site or deliveries to recycling facility in order to prevent contamination of recyclable materials.
 2. Coordinate work of recycling, composting and salvaging waste haulers with other trades.
 3. Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall accrue to Contractor.
- J. Reuse of materials On-Site: Set aside, sort, and protect separate products in preparation for reuse.
1. Materials qualifying as reused shall not be part of the waste diversion calculation. See Division 1 Section "Sustainable Design Requirements" requirements.
 2. Concrete, masonry and asphalt crushed and reused onsite shall contribute to Sustainable Design Requirements. See Division 1 Section "Sustainable Design Requirements".
 3. Stone excavated from the site, crushed and reused on site shall contribute Sustainable Design Requirements. See Division 1 Section "Sustainable Design Requirements".
- K. Salvage of Materials: Set aside, sort, and protect products to be salvaged for reuse offsite.
- L. Hazardous Waste Handling: Separate, store and dispose of hazardous wastes separately and in accordance with local regulations. Do not handle, separate, store, salvage, or recycle hazardous. Properly package, mark and label hazardous waste and dispose of in accordance with applicable EPA and DOE regulations. Manifest for shipping hazardous waste must be signed by the NZP Hazardous Waste Coordinator and generator copies maintained on site.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 PLAN IMPLEMENTATION

- A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.
1. Comply with operation, termination, and removal requirements in Section 015000 "Temporary Facilities and Controls."
- B. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.
1. Distribute the waste management plan to everyone concerned within **three** days of submittal return.
 2. Distribute the waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.
- C. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.

2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

- A. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows: B.

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until installation.
4. Protect items from damage during transport and storage.
5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.

3.3 RECYCLING, DEMOLITION AND CONSTRUCTION WASTE, GENERAL

- A. General: Recycle paper and beverage containers used by on-site workers.
- B. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.
- C. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.
1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.
 - a. Inspect containers and bins for contamination and remove contaminated materials if found.
 2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
 4. Store components off the ground and protect from the weather.
 5. Remove recyclable waste from Owner's property and transport to recycling receiver or processor.

3.4 RECYCLING DEMOLITION WASTE

- A. Asphalt Paving: Grind asphalt
1. Crush asphaltic concrete paving and screen to comply with requirements in Section 312000 "Earth Moving" for use as general fill.
- B. Asphalt Paving: Break up and transport paving to asphalt-recycling facility.
- C. Concrete: Remove reinforcement and other metals from concrete and sort with other metals. C.

1. Crush concrete and screen to comply with requirements in Section 312000 "Earth Moving" for use as satisfactory soil for fill or subbase.
 - D. Masonry: Remove metal reinforcement, anchors, and ties from masonry and sort with other metals.
 1. Pulverize masonry to maximum
 - a. Crush masonry and screen to comply with requirements in Section 312000 "Earth Moving" for use as satisfactory soil for fill or subbase.
 - b. Crush masonry and screen to comply with requirements in Section 329300 "Plants" for use as mineral mulch.
 2. Clean and stack undamaged, whole masonry units on wood pallets.
 - E. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.
 - F. Metals: Separate metals by type.
 1. Structural Steel: Stack members according to size, type of member, and length.
 2. Remove and dispose of bolts, nuts, washers, and other rough hardware.
 - G. Metal Suspension System: Separate metal members including trim, and other metals from acoustical panels and tile and sort with other metals.
 - H. Piping: Reduce piping to straight lengths and store by type and size. Separate supports, hangers, valves, sprinklers, and other components by type and size.
- 3.5 RECYCLING CONSTRUCTION WASTE
- A. Packaging:
 1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
 2. Polystyrene Packaging: Separate and bag materials.
 3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
 4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.
 - B. Wood Materials:
 1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
 2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.
 - a. Comply with requirements in Section 329300 "Plants" for use of clean sawdust as organic mulch.
 - C. Gypsum Board: Stack large clean pieces on wood pallets or in containers and store in a dry location.
 1. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.
 - a. Comply with requirements in Section 329300 "Exterior Plants" for use of clean ground gypsum board as inorganic soil amendment.

3.6 DISPOSAL OF WASTE

- A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.
 - 1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Burning: Do not burn waste materials.
- C. Disposal: Remove waste materials from Owner's property and legally dispose of them.

END OF SECTION 017419

FOR REFERENCE ONLY

SECTION 01 7700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for contract close-out, including, but not limited to, the following:
 - 1. Final completion procedures.
 - 2. Warranties.
 - 3. Final cleaning.
 - 4. Repair of the Work.
- B. Related Requirements:
 - 1. Final Completion.
 - 2. Division 01 Section 012900 "Payment Procedures" for requirements for Applications for Payment.
 - 3. Division 01 Section 013233 "Photographic Documentation" for submitting Final Completion construction photographic documentation.
 - 4. Division 01 Section 016000 "Product Requirements" for warranties.
 - 5. Division 01 Section 017300 "Execution" for progress cleaning of Project site.
 - 6. Division 01 Section 017419 "Construction Waste Management and Disposal" for Sustainable Design related documentation requirements.
 - 7. Division 01 Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.
 - 8. Division 01 Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
 - 9. Division 01 Section 017900 "Demonstration and Training" for requirements for instructing COTR's personnel.

1.3 ACTION SUBMITTALS

- A. Product Data: For cleaning agents.
- B. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.
- C. Certified List of Incomplete Items: Final submittal at Final Completion.

1.4 CLOSEOUT SUBMITTALS

- A. Certificates of Release: From authorities having jurisdiction.
- B. Certificate of Insurance: For continuing coverage.
- C. Field Report: For pest control inspection.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Schedule of Maintenance Material Items: For maintenance material submittal items specified in other Sections.

1.6 FINAL COMPLETION PROCEDURES

- A. Definition: The date of Final Completion of the Project is the date, as confirmed by the COTR, when the Work is satisfactorily completed and accepted in accordance with the Contract Documents, as amended and/or modified.
- B. Preliminary Procedures: Before requesting final inspection to determine the date of Final Completion, complete the following:
1. Submit a final Application for Payment according to Division 01 Section "Payment Procedures."
 2. Submit certified copy of Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by COTR. The certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
 3. Arrange for final changeover of locks.
 4. Submit evidence of payment and transfer date of utility company accounts for those utilities previously billed to the Contractor during construction.
 5. Submit evidence that all regulatory agency permits and code requirements have been completed and recorded, as necessary.
 6. Submission of a signed, written statement that no damage has occurred to the Site as documented by the Final Photographic/Videotape Documentation report.
 7. Submit evidence of final, continuing insurance coverage complying with insurance requirements.
 8. Final Clean-up.
- C. Inspection: Submit a written request for final inspection for acceptance. On receipt of request, COTR will either proceed with inspection or notify Contractor of unfulfilled requirements. COTR will prepare a final Letter of Acceptance after inspection or will notify Contractor of construction that must be completed or corrected before letter will be issued.
1. Re-inspection: Request re-inspection when the Work identified in previous inspections as incomplete is completed or corrected.
- D. Final Application for Payment: Complete all requirements for transmittal of the Final Application for Payment in accordance with Division 01 Section "Payment Procedures", including submission of:
1. Final labor data and Construction Progress Schedule update.
 2. Certification, signed by the Contractor, that all Contract requirements, including Contract Modifications have been met.
 3. Release of assignment of claims or consent of surety submitted, as necessary.
 4. Return of all parking permits.
 5. Final Project Record Documents.

1.7 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

- A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction
 - 1. Organize list of spaces in sequential order,
 - 2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
 - 3. Include the following information at the top of each page:
 - a. Project name.
 - b. Date.
 - c. Name of Contractor.
 - d. Page number
 - e. Total number of pages
 - f. SI Project Number.

1.8 SUBMITTAL OF PROJECT WARRANTIES

- A. Time of Submittal: Submit written warranties on request of COTR for designated portions of the Work where commencement of warranties other than date of Substantial Completion is indicated, or when delay in submittal of warranties might limit COTR's rights under warranty.
- B. Partial Occupancy: Submit properly executed warranties within 15 days of completion of designated portions of the Work that are completed and occupied or used by COTR during construction period by separate agreement with Contractor.
- C. Organize warranty documents into an orderly sequence based on the table of contents of Project Manual. Organize in a PDF.
 - 1. Warranty Electronic File: Submit Warranties in a submittal package into a single indexed electronic PDF file with links enabling navigation to each item. Provide bookmarked table of contents at beginning of document.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.
 - 1. Use cleaning products that comply with Green Seal's GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 – EXECUTION

3.1 FINAL CLEANING

- A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

- B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
1. Complete the following cleaning operations before requesting inspection for certification of Completion for entire Project or for a designated portion of Project:
 - a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
 - b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
 - c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 - d. Remove tools, construction equipment, machinery, and surplus material from project site.
 - e. Remove snow and ice to provide safe access to building.
 - f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 - g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 - h. Sweep concrete floors broom clean in unoccupied spaces.
 - i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
 - j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
 - k. Remove labels that are not permanent.
 - l. Wipe surfaces of mechanical and electrical equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
 - m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
 - n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
 - o. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.
 - 1) Clean HVAC system in compliance with NADCA Standard 1992-01. Provide written report on completion of cleaning.
 - p. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
 - q. Leave Project clean and ready for occupancy.
- C. Construction Waste Disposal: Comply with waste disposal requirements in Section 015000 "Temporary Facilities and Controls" and Section 017419 "Construction Waste Management and Disposal."

3.2 REPAIR OF THE WORK

- A. Complete repair and restoration operations before requesting inspection for

determination of Substantial Completion.

- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specify condition.
1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
 2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that already show evidence of repair or restoration.
 - a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.
 3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
 4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION 017700

SECTION 01 7823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
 - 1. Operation and maintenance documentation directory.
 - 2. Emergency manuals.
 - 3. Operation manuals for systems, subsystems, and equipment.
 - 4. Product maintenance manuals.
 - 5. Systems and equipment maintenance manuals.
- B. Related Requirements:
 - 1. Section 013300 "Submittal Procedures" for submitting copies of submittals for operation and maintenance manuals.
 - 2. Section 019113 "General Commissioning Requirements" for verification and compilation of data into operation and maintenance manuals.
 - 3. Divisions 02 through 33 Sections for specific operation and maintenance manual requirements for the Work in those Sections.

1.3 DEFINITIONS

- A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.
- B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 CLOSEOUT SUBMITTALS

- A. Manual Content: Operations and maintenance manual content is specified in individual Specification Sections to be reviewed at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.
 - 1. COTR will comment on whether content of operations and maintenance submittals are acceptable.
 - 2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.
- B. Format: Submit operations and maintenance manuals in the following format:
 - 1. PDF electronic file. Assemble each manual into a composite electronically indexed file. Submit on digital media acceptable to COTR.
 - a. Name each indexed document file in composite electronic index with

applicable item name. Include a complete electronically linked operation and maintenance directory.

PART 2 - PRODUCTS

2.1 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY

- A. Directory: Prepare a single, comprehensive directory of emergency, operation, and maintenance data and materials, listing items and their location to facilitate ready access to desired information. Include a section in the directory for each of the following:
 - 1. List of documents.
 - 2. List of systems.
 - 3. List of equipment.
 - 4. Table of contents.
- B. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.
- C. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.
- D. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.
- E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

2.2 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

- A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:
 - 1. Title page.
 - 2. Table of contents.
 - 3. Manual contents.
- B. Title Page: Include the following information:
 - 1. Subject matter included in manual.
 - 2. Name and address of Project.
 - 3. Name and address of Owner.
 - 4. Date of submittal.
 - 5. Name and contact information for Contractor.
 - 6. Name and contact information for Construction Manager.
 - 7. Name and contact information for Architect.
 - 8. Name and contact information for Commissioning Authority.
 - 9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
 - 10. Cross-reference to related systems in other operation and maintenance manuals.
- C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.
- D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
- E. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.
 1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
 2. File Names and Bookmarks: Enable bookmarking of individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

2.3 EMERGENCY MANUALS

- A. Content: Organize manual into a separate section for each of the following:
 1. Type of emergency.
 2. Emergency instructions.
 3. Emergency procedures.
- B. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:
 1. Fire.
 2. Flood.
 3. Gas leak.
 4. Water leak.
 5. Power failure.
 6. Water outage.
 7. System, subsystem, or equipment failure.
 8. Chemical release or spill.
- A. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.
- D. Emergency Procedures: Include the following, as applicable:
 1. Instructions on stopping.
 2. Shutdown instructions for each type of emergency.
 3. Operating instructions for conditions outside normal operating limits.
 4. Required sequences for electric or electronic systems.
 5. Special operating instructions and procedures.

2.4 OPERATION MANUALS

- A. Content: In addition to the requirements in this Section, include operation data required in the individual Specification Sections and the following information:
1. System, subsystem, and equipment descriptions. Use designations for systems and equipment indicated on Contract Documents.
 2. Performance and design criteria if the Contractor has delegated design responsibility.
 3. Operating standards.
 4. Operating procedures.
 5. Operating logs.
 6. Wiring diagrams.
 7. Control diagrams.
 8. Piped system diagrams.
 9. Precautions against improper use.
 10. License requirements including inspection and renewal dates.
- B. Descriptions: Include the following:
1. Product name and model number. Use designations for products indicated on Contract Documents.
 2. Manufacturer's name.
 3. Equipment identification with serial number of each component.
 4. Equipment function.
 5. Operating characteristics.
 6. Limiting conditions.
 7. Performance curves.
 8. Engineering data and tests.
 9. Complete nomenclature and number of replacement parts.
- C. Operating Procedures: Include the following, as applicable:
1. Startup procedures.
 2. Equipment or system break-in procedures.
 3. Routine and normal operating instructions.
 4. Regulation and control procedures.
 5. Instructions on stopping.
 6. Normal shutdown instructions.
 7. Seasonal and weekend operating instructions.
 8. Required sequences for electric or electronic systems.
 9. Special operating instructions and procedures.
- D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
- E. Piped Systems: Diagram piping as installed and identify color-coding where required for identification.

2.5 PRODUCT MAINTENANCE MANUALS

- A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.
- B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and

telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

- C. Product Information: Include the following, as applicable:
 - 1. Product name and model number.
 - 2. Manufacturer's name.
 - 3. Color, pattern, and texture.
 - 4. Material and chemical composition.
 - 5. Reordering information for specially manufactured products.
- D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
 - 1. Inspection procedures.
 - 2. Types of cleaning agents to be used and methods of cleaning.
 - 3. List of cleaning agents and methods of cleaning detrimental to product.
 - 4. Schedule for routine cleaning and maintenance.
 - 5. Repair instructions.
- E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
- F. Warranties: Include copies of warranties and lists of circumstances and conditions that would affect validity of warranties.
 - 1. Include procedures to follow and required notifications for warranty claims.
 - 2. Provide any extended warranties offered by manufactures and/or installers (including labor) for any and all equipment for Owner to review.

2.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

- A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
- B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.
- C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
 - 1. Standard maintenance instructions and bulletins.
 - 2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
 - 3. Identification and nomenclature of parts and components.
 - 4. List of items recommended to be stocked as spare parts.
- D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
 - 1. Test and inspection instructions.

2. Troubleshooting guide.
 3. Precautions against improper maintenance.
 4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
 5. Aligning, adjusting, and checking instructions.
 6. Demonstration and training video recording, if available.
- E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semi-annual, and annual frequencies.
 2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.
- F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
- G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
- H. Warranties: Include copies of warranties and lists of circumstances and conditions that would affect validity of warranties.
1. Include procedures to follow and required notifications for warranty claims.
 2. Provide any extended warranties offered by manufacturers and/or installers (including labor) for any and all equipment for Owner to review.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

- A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals.
- B. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.
- C. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.
- D. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.
 1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
 2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.
- E. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a

tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.
- F. Drawings: Prepare drawings supplementing manufacturers printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.
1. Do not use original project record documents as part of operation and maintenance manuals.
 2. Comply with requirements of newly prepared record Drawings in Section 017839 "Project Record Documents."
- G. Comply with Section 017700 "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 017823

SECTION 01 7839 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for project record documents, including the following:
 - 1. Record Drawings.
 - 2. Record Specifications.
 - 3. Record Product Data.
 - 4. Miscellaneous record submittals.
- B. Related Requirements:
 - 1. Section 017300 "Execution" for final property survey.
 - 2. Section 017700 "Closeout Procedures" for general closeout procedures.
 - 3. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.

1.3 CLOSEOUT SUBMITTALS

- A. Record Drawings: Comply with the following:
 - a. Final Submittal:
 - 1) Submit electronic PDF of marked-up record prints.
- B. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.
- C. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.
 - 1. Where record Product Data is required as part of operation and maintenance manuals, submit duplicate marked-up Product Data as a component of manual.
- D. Miscellaneous Record Submittals: See other Specification Sections for miscellaneous record-keeping requirements and submittals in connection with various construction activities. Submit annotated PDF electronic files and directories of each submittal.
- E. Reports: Submit written report biweekly indicating items incorporated into project record documents concurrent with progress of the Work, including revisions, concealed conditions, field changes, product selections, and other notations incorporated.

PART 2 - PRODUCTS

1.1 RECORD DRAWINGS

- A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised drawings as modifications are issued.
1. Preparation: Mark record prints to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to provide information for preparation of corresponding marked-up record prints.
 - a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
 - b. Accurately record information in an acceptable drawing technique.
 - c. Record data as soon as possible after obtaining it.
 - d. Record and check the markup before enclosing concealed installations.
 - e. Cross-reference record prints to corresponding archive photographic documentation.
 2. Content: Types of items requiring marking include, but are not limited to, the following:
 - a. Dimensional changes to Drawings.
 - b. Revisions to details shown on Drawings.
 - c. Depths of foundations below first floor.
 - d. Locations and depths of underground utilities.
 - e. Revisions to routing of piping and conduits.
 - f. Revisions to electrical circuitry.
 - g. Actual equipment locations.
 - h. Duct size and routing.
 - i. Locations of concealed internal utilities.
 - j. Changes made by Change Order or Change Directive.
 - k. Changes made following Architect's written orders.
 - l. Details not on the original Contract Drawings.
 - m. Field records for variable and concealed conditions.
 - n. Record information on the Work that is shown only schematically.
 3. Mark the Contract Drawings and Shop Drawings completely and accurately. Mark record sets with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
 4. Mark important additional information that was either shown schematically or omitted from original Drawings.
 5. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.
 6. Mark each sheet with the designation "AS BUILT."
- B. Record Digital Data Files: Review marked-up record prints with COTR. When authorized, prepare a full set of corrected digital data files of the Contract Drawings, as follows:
1. Format: Same CAD program, version, and operating system as the original Contract Drawings and PDF copy.
 2. Format: ArcGIS, filegeodatabase
 3. Format: Annotated PDF electronic file with comment function enabled.
 4. Incorporate changes and additional information previously marked on record prints. Delete, redraw, and add details and notations where applicable. Mark each sheet/file with the designation "AS BUILT."

5. Refer instances of uncertainty to COTR for resolution.
- C. Newly Prepared Record Drawings: Prepare new Drawings instead of preparing record Drawings where Architect determines that neither the original Contract Drawings nor Shop Drawings are suitable to show actual installation.
1. New Drawings may be required when a Change Order is issued as a result of accepting an alternate, substitution, or other modification.
 2. Ask the COTR for proper scale and scope of detailing and notations required to record the actual physical installation and its relation to other construction. Integrate newly prepared record Drawings into record Drawing sets; comply with procedures for formatting, organizing, copying, binding, and submitting.
- D. Format: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.
1. Record Prints: Organize record prints and newly prepared Record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
 2. Format: Annotated PDF electronic file with comment function enabled.
 3. Record Digital Data Files: Organize digital data information into separate electronic files that correspond to each sheet of the Contract Drawings. Name each file with the sheet identification. Include identification in each digital data file.
 4. Identification: As follows:
 - a. Project name.
 - b. Date.
 - c. Designation "PROJECT RECORD DRAWINGS."
 - d. Name of Contractor.

1.2 RECORD SPECIFICATIONS

- A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.
1. Give particular attention to information on concealed products and installations that cannot be readily identified and reordered later.
 2. Mark copies with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
 3. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.
 4. For each principal product, indicate whether record Product Data has been submitted in operation and maintenance manuals instead of submitted as record Product Data.
 5. Note related Change Orders, record Product Data, and record Drawings where applicable.
 6. Mark cover sheet with the designation "AS BUILT."
- A. Format: Submit record Specifications as annotated PDF electronic file of marked-up paper copy of Specifications.

1.3 RECORD PRODUCT DATA

- A. Preparation: Mark Product Data to indicate the actual product installation where

installation varies substantially from that indicated in Product Data submittal.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
2. Include significant changes in the product delivered to Project site and changes in manufacturers' written instructions for installation.
3. Note related Change Orders, record Specifications, and record Drawings where applicable.
4. Mark each cover sheet with the designation "AS BUILT."

B. Format: Submit record Product Data as annotated PDF electronic file of marked-up paper copy of Product Data.

1. Include record Product Data directory organized by Specification Section number and title, electronically linked to each item of record Product Data.

1.4 MISCELLANEOUS RECORD SUBMITTALS

A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

B. Format: Submit miscellaneous record submittals as PDF electronic file of marked-up miscellaneous record submittals.

1. Include miscellaneous record submittals directory organized by Specification Section number and title, electronically linked to each item of miscellaneous record submittals.

PART 3 - EXECUTION

1.1 RECORDING AND MAINTENANCE

A. Recording: Maintain one copy of each submittal during the construction period for project record document purposes. Post changes and revisions to project record documents as they occur; do not wait until end of Project.

B. Maintenance of Record Documents and Samples: Store record documents and Samples in the field office apart from the Contract Documents used for construction. Do not use project record documents for construction purposes. Maintain record documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to project record documents for COTR reference during normal working hours.

END OF SECTION 017839

SECTION 01 7900 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes administrative and procedural requirements for instructing COTR's personnel, including the following:

1. Demonstration of operation of systems, subsystems, and equipment.
2. Training in operation and maintenance of systems, subsystems, and equipment.
3. Demonstration and training video recordings.

1.3 INFORMATIONAL SUBMITTALS

A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

1. Indicate proposed training modules using manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.

B. Qualification Data: For facilitator, instructor, and videographer.

C. Attendance Record: For each training module, submit list of participants and length of instruction time.

D. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

E. Related Sections include the following:

1. Division 01 Section 013100 "Project Management and Coordination" for requirements for pre-instruction conferences.
2. Division 01 Section 013233 "Photographic Documentation" for preparing and submitting demonstration and training videotapes.
3. Division 01 Section 019113 "General Commissioning Requirements"

F. Allowances: Where training and demonstration requirements are not provided in the technical specifications sections, allow for a one-hour minimum demonstration period for each system or piece of equipment.

G. Demonstration and Training Videotape: Submit two copies at end of each training module.

1.4 CLOSEOUT SUBMITTALS

A. Demonstration and Training Video Recordings: Submit electronically within seven days of end of each training module.

1. Identification: Provide a Submittal with the following information:
 - a. Name of Project.
 - b. Name and address of videographer.
 - c. Name of Architect.
 - d. Name of Construction Manager.
 - e. Name of Contractor.
 - f. Date of video recording.
2. Transcript: Prepared and bound in format matching operation and maintenance manuals. Mark appropriate identification on front and spine of each binder. Include a cover sheet with same label information as the corresponding video recording. Include name of Project and date of video recording on each page.
3. Transcript: Prepared in PDF electronic format. Include a cover sheet with same label information as the corresponding video recording and a table of contents with links to corresponding training components. Include name of Project and date of video recording on each page.
4. At completion of training, submit complete training manual(s) for COTR's use prepared and bound in format matching operation and maintenance manuals and in PDF electronic file format on compact disc.

1.5 QUALITY ASSURANCE

- A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.
- B. Instructor Qualifications: A factory-authorized service representative, complying with requirements in Section 014000 "Quality Requirements," experienced in operation and maintenance procedures and training.
- C. Videographer Qualifications: A videographer who is experienced photographing demonstration and training events like those required.
- D. Pre-instruction Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to demonstration and training including, but not limited to, the following:
 1. Inspect and discuss locations and other facilities required for instruction.
 2. Review and finalize instruction schedule and verify availability of educational materials, instructors' personnel, audiovisual equipment, and facilities needed to avoid delays.
 3. Review required content of instruction.
 4. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

1.6 COORDINATION

- A. Coordinate instruction schedule with COTR's operations. Adjust schedule as required to minimize disrupting COTR's operations and to ensure availability of COTR's personnel.
- B. Coordinate instructors, including providing notification of dates, times, length of instruction time,

and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and maintenance manuals. Do not submit instruction program until operation and maintenance data has been reviewed and approved by COTR.

PART 2 - PRODUCTS

2.1 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each

system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. Basis of System Design, Operational Requirements, and Criteria: Include the following:
 - a. System, subsystem, and equipment descriptions.
 - b. Performance and design criteria if Contractor are delegated design responsibility.
 - c. Operating standards.
 - d. Regulatory requirements.
 - e. Equipment function.
 - f. Operating characteristics.
 - g. Limiting conditions.
 - h. Performance curves.
2. Documentation: Review the following items in detail:
 - a. Emergency manuals.
 - b. Operations manuals.
 - c. Maintenance manuals.
 - d. Project record documents.
 - e. Identification systems.
 - f. Warranties and bonds.
 - g. Maintenance service agreements and similar continuing commitments.
3. Emergencies: Include the following, as applicable:
 - a. Instructions on meaning of warnings, trouble indications, and error messages.
 - b. Instructions on stopping.
 - c. Shutdown instructions for each type of emergency.
 - d. Operating instructions for conditions outside of normal operating limits.
 - e. Sequences for electric or electronic systems.
 - f. Special operating instructions and procedures.
4. Operations: Include the following, as applicable:
 - a. Startup procedures.
 - b. Equipment or system break-in procedures.
 - c. Routine and normal operating instructions.
 - d. Regulation and control procedures.
 - e. Control sequences.
 - f. Safety procedures.
 - g. Instructions on stopping.

- h. Normal shutdown instructions.
 - i. Operating procedures for emergencies.
 - j. Operating procedures for system, subsystem, or equipment failure.
 - k. Seasonal and weekend operating instructions.
 - l. Required sequences for electric or electronic systems.
 - m. Special operating instructions and procedures.
5. Adjustments: Include the following:
- a. Alignments.
 - b. Checking adjustments.
 - c. Noise and vibration adjustments.
 - d. Economy and efficiency adjustments.
6. Troubleshooting: Include the following:
- a. Diagnostic instructions.
 - b. Test and inspection procedures.
7. Maintenance: Include the following:
- a. Inspection procedures.
 - b. Types of cleaning agents to be used and methods of cleaning.
 - c. List of cleaning agents and methods of cleaning detrimental to product.
 - d. Procedures for routine cleaning
 - e. Procedures for preventive maintenance.
 - f. Procedures for routine maintenance.
 - g. Instruction on use of special tools.
8. Repairs: Include the following:
- a. Diagnosis instructions.
 - b. Repair instructions.
 - c. Disassembly; component removal, repair, and replacement; and reassembly instructions.
 - d. Instructions for identifying parts and components.
 - e. Review of spare parts needed for operation and maintenance.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a training manual organized in coordination with requirements in Section 017823 "Operation and Maintenance Data."
- B. Set up instructional equipment at instruction location.

3.2 INSTRUCTION

- A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and COTR for number of participants, instruction times, and location.
- B. Engage qualified instructors to instruct COTR's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.
- C. Scheduling: Provide instruction at mutually agreed on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with COTR with at least seven days' advance notice.

D. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.

E. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of a performance-based test if required by the COTR.

F. Cleanup: Collect used and leftover educational materials and give to COTR. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

3.3 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Engage a qualified videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Video: Provide minimum 640 x 480 video resolution converted to format file type acceptable to COTR on electronic media.

1. Electronic Media: Read-only format compact disc acceptable to COTR, with commercial-grade graphic label.

2. File Hierarchy: Organize folder structure and file locations according to project manual table of contents. Provide complete screen-based menu.

3. File Names: Utilize file names based upon name of equipment generally described in video segment, as identified in Project specifications.

4. Contractor and Installer Contact File: Using appropriate software, create a file for inclusion on the Equipment Demonstration and Training flash drive that describes the following for each Contractor involved on the Project, arranged according to Project table of contents:

- a. Name of Contractor/Installer.
- b. Business address.
- c. Business phone number.
- d. Point of contact.
- e. E-mail address.

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to adequately cover area of demonstration and training. Display continuous running time.

1. Film training session(s) in segments not to exceed 15 minutes.

- a. Produce segments to present a single significant piece of equipment per segment.
- b. Organize segments with multiple pieces of equipment to follow order of Project Manual table of contents.
- c. Where a training session on a piece of equipment exceeds 15 minutes, stop

filming, and
pause training session. Begin training session again upon commencement of new
filming segment.

D. Light Levels: Verify light levels are adequate to properly light equipment. Verify equipment
markings
are clearly visible prior to recording.

1. Furnish additional portable lighting as required.

E. Narration: Describe scenes on video recording by audio narration by microphone while video
recording is recorded. Include description of items being viewed.

F. Transcript: Provide a transcript of the narration. Display images and running time captured from
videotape opposite the corresponding narration segment.

G. Pre-produced Video Recordings: Provide video recordings used as a component of training
modules
in same format as recordings of live training.

END OF SECTION 017900

FOR REFERENCE ONLY

SECTION 01 8113 - SUSTAINABLE DESIGN REQUIREMENTS – LEED

Part 1- GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements and procedures for compliance with certain USGBC LEED prerequisites and credits needed for Project to obtain **LEED Gold** certification based on USGBC's "LEED 2009 for New Construction & Major Renovations."
 - 1. Other LEED prerequisites and credits needed to obtain LEED certification depend on product selections and may not be specifically identified as LEED requirements. Compliance with requirements needed to obtain LEED prerequisites and credits may be used as one criterion to evaluate substitution requests and comparable product requests.
 - 2. Additional LEED prerequisites and credits needed to obtain the indicated LEED certification depend on Architect's design and other aspects of Project that are not part of the Work of the Contract.
 - 3. A copy of the LEED Project checklist is attached at the end of this Section for information only.
 - 4. Specific requirements for LEED are included in greater detail in other Sections.

1.3 DEFINITIONS

- A. Chain-of-Custody Certificates: Certificates signed by manufacturers certifying that wood used to make products was obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship." Certificates shall include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.
- B. Regional Materials: Materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.
- C. Recycled Content: The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.
 - 1. "Post-consumer" material is defined as waste material generated by households or by commercial, industrial, and institutional facilities in their role as end users of the product, which can no longer be used for its intended purpose.
 - 2. "Pre-consumer" material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Respond to questions and requests from Architect and the USGBC regarding LEED credits that are the responsibility of the Contractor, that depend on product selection or product qualities, or that depend on

Contractor's procedures until the USGBC has made its determination on the project's LEED certification application. Document responses as informational submittals.

- B. The Contractor is responsible for achieving the minimum amount of Construction related credits outlined within the LEED Scorecard.
- C. The Contractor is responsible for submitting all Construction related credits to USGBC through the LEED Online platform.

1.5 ACTION SUBMITTALS

- A. General: Submit additional LEED submittals required by other Specification Sections.
- B. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
- C. LEED Documentation Submittals:
 - 1. Credit EA 5: Product data and wiring diagrams for sensors and data collection system used to provide continuous metering of building energy-consumption performance over a period of time of not less than one year of postconstruction occupancy.
 - 2. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."
 - 3. Credit MR 3: Receipts for salvaged and refurbished materials used for Project, indicating sources and costs for salvaged and refurbished materials.
 - 4. Credit MR 4: Product data and certification letter from product manufacturers indicating percentages by weight of post-consumer and pre-consumer recycled content for products having recycled content. Include statement indicating material cost for each product having recycled content.
 - 5. Credit MR 5: Product data for regional materials indicating location and distance from Project of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating cost for each regional material and the fraction by weight that is considered regional.
 - 6. Credit MR 7: Product data and chain-of-custody certificates for products containing certified wood. Include statement indicating cost for each certified wood product.
 - 7. Credit IEQ 3.1:
 - a. Construction indoor-air-quality management plan.
 - b. Product data for temporary filtration media.
 - c. Product data for filtration media used during occupancy.
 - d. Construction Documentation: Six photographs at three different times during the construction period, along with a brief description of the SMACNA approach employed, documenting implementation of the indoor-air-quality management measures, such as protection of ducts and on-site stored or installed absorptive materials.
 - 8. Credit IEQ 3.2:
 - a. Signed statement describing the building air flush-out procedures including the dates when flush-out was begun and completed and statement that filtration media was replaced after flush-out.
 - b. Product data for filtration media used during flush-out and during occupancy.
 - c. Report from testing and inspecting agency indicating results of indoor-air-quality testing and documentation showing compliance with indoor-air-quality testing procedures and requirements.

9. Credit IEQ 4.1: Product data for adhesives and sealants used inside the weatherproofing system indicating VOC content of each product used.
10. Credit IEQ 4.2: Product data for paints and coatings used inside the weatherproofing system indicating VOC content of each product used.
11. Credit IEQ 4.4: Product data for products containing composite wood or Agri fiber products or wood glues indicating that they do not contain urea-formaldehyde resin.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For LEED coordinator.
- B. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project. Costs exclude labor, overhead, and profit. Include breakout of costs for the following categories of items:
 1. Furniture.
 2. Plumbing.
 3. Mechanical.
 4. Electrical.
 5. Specialty items such as elevators and equipment.
 6. Wood-based construction materials.
- C. LEED Action Plans: Provide preliminary submittals within 14 days of date established for the Notice to Proceed indicating how the following requirements will be met:
 1. Credit MR 2: Waste management plan complying with Section 017419 "Construction Waste Management and Disposal."
 2. Credit MR 3: List of proposed salvaged, refurbished, and reused materials. Identify each material that will be salvaged, refurbished, or reused, including its source, cost, and replacement cost if the item was to be purchased new.
 3. Credit MR 4: List of proposed materials with recycled content. Indicate cost, post-consumer recycled content, and pre-consumer recycled content for each product having recycled content.
 4. Credit MR 5: List of proposed regional materials. Identify each regional material, including its source, cost, and the fraction by weight that is considered regional.
 5. Credit MR 7: List of proposed certified wood products. Indicate each product containing certified wood, including its source and cost of certified wood products.
 6. Credit IEQ 3.1: Construction indoor-air-quality management plan.
- D. LEED Progress Reports: Concurrent with each Application for Payment, submit reports comparing actual construction and purchasing activities with LEED action plans for the following:
 1. Credit MR 2: Waste reduction progress reports complying with Section 017419 "Construction Waste Management and Disposal."
 2. Credit MR 3: Salvaged, refurbished, and reused materials.
 3. Credit MR 4: Recycled content.
 4. Credit MR 5: Regional materials.
 5. Credit MR 7: Certified wood products.

1.7 QUALITY ASSURANCE

- A. LEED Coordinator: Engage an experienced LEED-Accredited Professional to coordinate LEED requirements. LEED coordinator may also serve as waste management coordinator.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Provide products and procedures necessary to obtain LEED credits required in this Section. Although other Sections may specify some requirements that contribute to LEED credits, the Contractor shall determine additional materials and procedures necessary to obtain LEED credits indicated.

2.2 SALVAGED, REFURBISHED, OR REUSED MATERIALS

- A. Credit MR 3: Not less than 5 percent of building materials (by cost) shall be salvaged, refurbished, or reused materials.

2.3 RECYCLED CONTENT OF MATERIALS

- A. Credit MR 4: Building materials shall have recycled content such that post-consumer recycled content plus one-half of pre-consumer recycled content for Project constitutes a minimum of 20 percent of cost of materials used for Project.
 - 1. Cost of post-consumer recycled content plus one-half of pre-consumer recycled content of an item shall be determined by dividing weight of post-consumer recycled content plus one-half of pre-consumer recycled content in the item by total weight of the item and multiplying by cost of the item.
 - 2. Do not include furniture, plumbing, mechanical and electrical components, and specialty items such as elevators and equipment in the calculation.

2.4 REGIONAL MATERIALS

- A. Credit MR 5: Not less than 10 percent of building materials (by cost) shall be regional materials.

2.5 CERTIFIED WOOD

- A. Credit MR 7: Not less than 50 percent (by cost) of wood-based materials shall be produced from wood obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."
 - 1. Wood-based materials include, but are not limited to, the following materials when made from wood, engineered wood products, or wood-based panel products:
 - a. Rough carpentry.
 - b. Miscellaneous carpentry.
 - c. Heavy timber construction.
 - d. Wood decking.
 - e. Metal-plate-connected wood trusses.
 - f. Structural glued-laminated timber.
 - g. Finish carpentry.
 - h. Architectural woodwork.
 - i. Wood paneling.
 - j. Wood veneer wall covering.
 - k. Wood flooring.

- l. Wood lockers.
- m. Wood cabinets.
- n. Furniture.

2.6 LOW-EMITTING MATERIALS

- A. Credit IEQ 4.1: For field applications that are inside the weatherproofing system, adhesives and sealants shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Wood Glues: 30 g/L.
2. Metal-to-Metal Adhesives: 30 g/L.
3. Adhesives for Porous Materials (Except Wood): 50 g/L.
4. Subfloor Adhesives: 50 g/L.
5. Plastic Foam Adhesives: 50 g/L.
6. Carpet Adhesives: 50 g/L.
7. Carpet Pad Adhesives: 50 g/L.
8. VCT and Asphalt Tile Adhesives: 50 g/L.
9. Cove Base Adhesives: 50 g/L.
10. Gypsum Board and Panel Adhesives: 50 g/L.
11. Rubber Floor Adhesives: 60 g/L.
12. Ceramic Tile Adhesives: 65 g/L.
13. Multipurpose Construction Adhesives: 70 g/L.
14. Fiberglass Adhesives: 80 g/L.
15. Contact Adhesive: 80 g/L.
16. Structural Glazing Adhesives: 100 g/L.
17. Wood Flooring Adhesive: 100 g/L.
18. Structural Wood Member Adhesive: 140 g/L.
19. Single-Ply Roof Membrane Adhesive: 250 g/L.
20. Special-Purpose Contact Adhesive (contact adhesive that is used to bond melamine-covered board, metal, unsupported vinyl, rubber, or wood veneer 1/16 inch or less in thickness to any surface): 250 g/L.
21. Top and Trim Adhesive: 250 g/L.
22. Plastic Cement Welding Compounds: 250 g/L.
23. ABS Welding Compounds: 325 g/L.
24. CPVC Welding Compounds: 490 g/L.
25. PVC Welding Compounds: 510 g/L.
26. Adhesive Primer for Plastic: 550 g/L.
27. Sheet-Applied Rubber Lining Adhesive: 850 g/L.
28. Aerosol Adhesive, General-Purpose Mist Spray: 65 percent by weight.
29. Aerosol Adhesive, General-Purpose Web Spray: 55 percent by weight.
30. Special-Purpose Aerosol Adhesive (All Types): 70 percent by weight.
31. Other Adhesives: 250 g/L.
32. Architectural Sealants: 250 g/L.
33. Nonmembrane Roof Sealants: 300 g/L.
34. Single-Ply Roof Membrane Sealants: 450 g/L.
35. Other Sealants: 420 g/L.
36. Sealant Primers for Nonporous Substrates: 250 g/L.
37. Sealant Primers for Porous Substrates: 775 g/L.
38. Modified Bituminous Sealant Primers: 500 g/L.
39. Other Sealant Primers: 750 g/L.

- B. Credit IEQ 4.2: For field applications that are inside the weatherproofing system, paints and coatings shall comply with the following VOC content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24):

1. Flat Paints and Coatings: VOC not more than 50 g/L.
 2. Nonflat Paints and Coatings: VOC not more than 150 g/L.
 3. Dry-Fog Coatings: VOC not more than 400 g/L.
 4. Primers, Sealers, and Undercoaters: VOC not more than 200 g/L.
 5. Anticorrosive and Antirust Paints Applied to Ferrous Metals: VOC not more than 250 g/L.
 6. Zinc-Rich Industrial Maintenance Primers: VOC not more than 340 g/L.
 7. Pretreatment Wash Primers: VOC not more than 420 g/L.
 8. Clear Wood Finishes, Varnishes: VOC not more than 350 g/L.
 9. Clear Wood Finishes, Lacquers: VOC not more than 550 g/L.
 10. Floor Coatings: VOC not more than 100 g/L.
 11. Shellacs, Clear: VOC not more than 730 g/L.
 12. Shellacs, Pigmented: VOC not more than 550 g/L.
 13. Stains: VOC not more than 250 g/L.
- C. Credit IEQ 4.4: Composite wood, agrifiber products, and adhesives shall not contain urea-formaldehyde resin.

PART 3 - EXECUTION

3.1 REFRIGERANT AND CLEAN-AGENT FIRE-EXTINGUISHING-AGENT REMOVAL

- A. Prerequisite EA 3: Remove CFC-based refrigerants from existing HVAC&R equipment indicated to remain and replace with refrigerants that are not CFC based. Replace or adjust existing equipment to accommodate new refrigerant as described in HVAC Sections.
- B. Credit EA 4: Remove clean-agent fire-extinguishing agents that contain HCFCs or halons and replace with agent that does not contain HCFCs or halons. See Section 212200 "Clean-Agent Fire-Extinguishing Systems" for additional requirements.

3.2 MEASUREMENT AND VERIFICATION

- A. Credit EA 5: Implement measurement and verification plan consistent with Option B: Energy Conservation Measure Isolation the EVO's "International Performance Measurement and Verification Protocol (IPMVP), Volume III: Concepts and Options for Determining Energy Savings in New Construction,".
- B. If not already in place, install metering equipment to measure energy usage. Monitor, record, and trend log measurements.
- C. Evaluate energy performance and efficiency by comparing actual to predicted performance.
- D. Measurement and verification period shall cover at least one year of postconstruction occupancy.

3.3 CONSTRUCTION WASTE MANAGEMENT

- A. Credit MR 2: Comply with Section 017419 "Construction Waste Management and Disposal."

3.4 CONSTRUCTION INDOOR-AIR-QUALITY MANAGEMENT

- A. Credit IEQ 3.1: Comply with SMACNA's "SMACNA IAQ Guideline for Occupied Buildings under Construction."

1. If Owner authorizes use of permanent heating, cooling, and ventilating systems during construction period as specified in Section 015000 "Temporary Facilities and Controls," install filter media having a MERV 8 according to ASHRAE 52.2 at each return-air inlet for the air-handling system used during construction.
2. Replace all air filters immediately prior to occupancy.

B. Credit IEQ 3.2: Comply with one of the following requirements:

1. After construction ends, prior to occupancy and with all interior finishes installed, perform a building flush-out by supplying a total volume of 14000 cu. ft. of outdoor air per sq. ft. of floor area while maintaining an internal temperature of at least 60 deg F and a relative humidity no higher than 60 percent.
2. If occupancy is desired prior to flush-out completion, the space may be occupied following delivery of a minimum of 3500 cu. ft. of outdoor air per sq. ft. of floor area to the space. Once a space is occupied, it shall be ventilated at a minimum rate of 0.30 cfm per sq. ft. of outside air or the design minimum outside air rate determined in Prerequisite IEQ 1, whichever is greater. During each day of the flush-out period, ventilation shall begin a minimum of three hours prior to occupancy and continue during occupancy. These conditions shall be maintained until a total of 14000 cu. ft./sq. ft. of outside air has been delivered to the space.
3. Air-Quality Testing:
 - a. Conduct baseline indoor-air-quality testing, after construction ends and prior to occupancy, using testing protocols consistent with the EPA's "Compendium of Methods for the Determination of Air Pollutants in Indoor Air," and as additionally detailed in the USGBC's "Green Building Design and Construction Reference Guide."
 - b. Demonstrate that the contaminant maximum concentrations listed below are not exceeded:
 - 1) Formaldehyde: 27 ppb
 - 2) Particulates (PM10): 50 micrograms/cu. m.
 - 3) Total Volatile Organic Compounds (TVOC): 500 micrograms/cu. m.
 - 4) 4-Phenylcyclohexene (4-PH): 6.5 micrograms/cu. m.
 - 5) Carbon Monoxide: 9 ppm and no greater than 2 ppm above outdoor levels.
 - c. For each sampling point where the maximum concentration limits are exceeded, conduct additional flush-out with outside air and retest the specific parameter(s) exceeded to indicate the requirements are achieved. Repeat procedure until all requirements have been met. When retesting noncomplying building areas, take samples from same locations as in the first test.
 - d. Air-sample testing shall be conducted as follows:
 - 1) All measurements shall be conducted prior to occupancy but during normal occupied hours, and with building ventilation system starting at the normal daily start time and operated at the minimum outside air flow rate for the occupied mode throughout the duration of the air testing.
 - 2) Building shall have all interior finishes installed including, but not limited to, millwork, doors, paint, carpet, and acoustic tiles. Nonfixed furnishings such as workstations and partitions are encouraged, but not required, to be in place for the testing.
 - 3) Number of sampling locations varies depending on the size of building and number of ventilation systems. For each portion of building served by a separate ventilation system, the number of sampling points shall not be less than one per 25,000 sq. ft. or

- for each contiguous floor area, whichever is larger, and shall include areas with the least ventilation and greatest presumed source strength.
- 4) Air samples shall be collected between 3 and 6 feet from the floor to represent the breathing zone of occupants, and over a minimum four-hour period.

END OF SECTION 018113

FOR REFERENCE ONLY

SECTION 01 9113 – COMMISSIONING**PART 1 – GENERAL****1.1 Description**

- A. The Smithsonian will procure the services of independent Commissioning Consultant; other terms are Commissioning Provider, Commissioning Agent, and Commissioning Authority. The Commissioning Consultant is an independent and knowledgeable third party, contracted to verify that the systems work as described in the Owners Project Requirements (OPR). The Commissioning Consultant will inform the Construction Manager (CM) COTR and the Architect of the results of the commissioning and provide suggestions, as necessary, to correct deficiencies in observed performance or installation.
- B. Commissioning is the process to verify to the Smithsonian that systems, equipment, mechanical, electrical, controls and special systems function together properly to meet performance requirements and design intent, and as described in the Contract Documents. The General Contractor shall be responsible for participation in the commissioning process as outlined below and in references and attachments throughout the Contract Documents. The General Contractor shall furnish labor and materials sufficient to meet all requirements of building commissioning under this contract.
- C. Various sections in Division 23 and 26 Specifications as well as specifications in other formats outline the specific commissioning responsibilities of each General Contractor and corresponding subcontractors for the division and obligate the General Contractor to coordinate and manage the commissioning responsibility of those subcontractors.

1.2 REQUIREMENTS INCLUDED

- A. Duties of Contractor.
- B. Duties of Commissioning Consultant.
- C. Commissioning Field Notebook.
- D. Acceptance Procedures.
- E. Performance Period.
- F. Training and Instruction.

1.3 RELATED SECTIONS

- A. All Division 1 Sections and Smithsonian General Requirements
- B. All Division 21 Sections
- C. All Division 22 Sections
- D. All Division 23 Sections
- E. All Division 25 Sections
- F. All Division 26 Sections
- G. All Division 28 Sections

1.4 TERMS

- A. Acceptable Performance: A component or system being able to meet specified design parameters under actual load including satisfactory documented completion of all functional performance tests, control system trending and resolution of outstanding issues.
- B. Basis of Design: The Basis of Design is a document that records the concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process. (ASHRAE Guideline 0-2013). The Basis of Design

provided by the design engineer addresses the decisions to meet the design intent as defined by the Smithsonian Institution. The Basis of Design describes the systems, components, conditions, and methods to meet the design intent.

- C. Commissioning Plan: The Smithsonian's Commissioning Consultant prepares The Commissioning Plan. *The Commissioning plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process (ASHRAE Guideline 0-2013).* In addition, it defines the scope and format of the commissioning process and the responsibilities of all involved parties. The commissioning team reviews the Commissioning Plan to inform the intent and scope of the commissioning process, to ensure inclusion in the construction project scope/schedule and to facilitate and expedite the commissioning process. The Commissioning Plan is to be distributed by the Commissioning Consultant during the first third of the construction timeframe.
- D. Functional Performance Testing: Is a full range of checkouts and tests carried out to determine if all components, sub-systems, systems, and interfaces between systems function in accordance with the Contract Documents and meets the design intent. In this context, "function" includes all modes and sequences of control operation, all interlocks and conditional control responses and all specified responses to abnormal emergency conditions. The Commissioning Consultant will prepare the functional performance tests.
- E. Commissioning (Also Commissioning Process) is *a quality-focused process enhancing the delivery of a project. The process focusses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements. (ASHRAE Guideline 0-2013).* Process to demonstrate the Smithsonian building equipment controls and systems function together properly to meet design intent and performance requirements shown in a composite manner in the Contract Documents.
- F. Resolution Log: The purpose of this document is to provide a method for tracking and resolution of deficiencies discovered during the commissioning process. This list also includes the current disposition of issues and the date of final resolution as confirmed by the Commissioning Consultant. Deficiencies are issues where products, execution or performance does not satisfy the Specifications and/or the design intent. The Commissioning consultant creates and manages the Resolution Log.
- G. Pre-functional Construction Checklists: Commissioning Consultant prepares Checklist for equipment of systems and assemblies. See paragraph 1. A. Checklist shall be for the systems or equipment involved in the commissioning process to verify installation and start-up of equipment is complete and verify that systems are ready for functional testing. These documents require signature by the Contractor prior to continuing with the commissioning process and are required as a pre-condition of beginning the Functional Performance Testing.
- H. Testing and balancing (TAB) process. A complete pencil copy of TAB reports, reviewed on a system-by-system basis by the engineer and the Cx entity, is required prior to the start of any final functional performance test.

1.5 DUTIES OF CONTRACTOR

- A. Provide copies of all approved shop drawings, manufacturer's literature, maintenance information or other information as may be needed for systems and assemblies to the Commissioning Consultant.
- B. Collect the information requested by Commissioning Consultant for development of a complete Commissioning Plan, Commissioning Field Notebook, and Functional Performance Tests and provide to the Commissioning Consultant. The General Contractor shall review the Commissioning Plan, Commissioning Field Notebook, and Functional performance Test and confirm in writing to the CM COTR, Architect and Commissioning Consultant any known areas of conflict or areas requiring clarifications.
- C. Collect all proposed equipment start-up and Pre-Functional Construction Checklists documentation and place

it into the Commissioning Field Notebook. The General Contractor will provide the Commissioning Consultant with the completed commissioning field notebook.

- D. Provide the Contractor's schedule to the commissioning Consultant for review and comment. Plan for and incorporate commissioning activities into the construction schedule. Provide a sufficient detailed level of scheduling, activity, and detail to properly coordinate and schedule the trades. Provide a detailed Commissioning Schedule Fragnet to the project schedule, updated monthly reflecting actual construction progress.
- E. Provide Commissioning Consultant with submittals for all systems and assemblies for review and comments. Include submittals of controls system and wiring diagrams and narrative sequences of operation, in time for use in preparing the Functional Test Procedures. The Commissioning Consultant review comments of pertinent submittals is coordinated through the Construction Manager COTR.
- F. Provide a fully operational system per Specifications, started, verified, debugged, calibrated, balanced, tested and under automatic control.
- G. Provide qualified personnel to participate in the commissioning tests, including seasonal testing.
- H. Cooperate with the Commissioning Consultant's personnel.
- I. Provide access to site for the Commissioning Consultant for review, verification and testing activities.
- J. Provide organized storage space for project drawings, Specifications, equipment and materials submittals, shop drawings and operation and maintenance manuals in the job site trailers or job site office space.
- K. Provide updates to all project documentation to reflect all supplemental instructions, addenda or other revisions to the project construction documents. Updates and architect's supplemental instructions must be posted to the master set of documentation for review and reference by all Contractors and for the Commissioning Consultant's use.
- L. Provide adequate time and resources to perform functional testing of systems and assemblies in contract. These times and activities shall be reflected in the Commissioning Fragnet schedule, updated monthly.
- M. Coordinate participation of all pertinent subcontractors including mechanical, electrical, controls and Testing and Balancing TAB subcontractors in the commissioning process.
- N. Participate in any efforts to finalize sequences of operations with Construction Manager COTR, Designers and Commissioning Consultant.
- O. Verify that coordination, installation, quality control and final testing have been completed such that installed systems and equipment comply with construction documents.
- P. Review the Commissioning Plan, Project Reports and test results and submit comments to the Commissioning Authority.
- Q. In a timely manner, address issues identified during construction that may affect the commissioning process or final system performance.
- R. Perform equipment start-up and testing of mechanical and electrical equipment and systems and document as required with start-up reports and completion of Pre-functional Construction Checklists. These checklists include installation documentation, start-up documentation, controls point-to-point documentation and calibration documentation, verification that controls sequence of operations meets design intent and TAB final documentation. Reports will be stored in the Contractor's field trailer, as a part of the Commissioning Field Notebook. Contractor will coordinate efforts to complete the pre-functional documentation.

- S. Lead verification testing of fire/smoke dampers and direct the resolution of deficiencies. Each fire/smoke damper and its functions are tracked in a matrix spreadsheet. Owner's Authority Having Jurisdiction (OSHEM) shall witness and approve all life safety systems including fire / smoke damper operation.
- T. Provide preliminary TAB report, indicating all actual field values recorded to the Commissioning Consultant through the Construction Manager COTR, prior to initiation of functional testing. These reports shall be incorporated in the commissioning field notebook. Provide these "pencilcopy" TAB data on a system-by-system basis, as systems have been finally and completely balanced.
- U. Pre-test all systems prior to scheduling the final Functional Performance Test for the record. Operate equipment and systems as required in preparation of final functional performance testing. This includes but is not limited to manipulating the appropriate controls systems to execute the Functional Test Procedures.
- V. The Contractor shall issue a written Notice of Readiness for each system; include verification of system completion, TAB completion and controls. Provide the Commissioning Consultant with a copy of the Notice of Readiness upon completion of all systems work, start-up and Pre-functional Construction Checklists requirements by trade contractors.
- W. Participate in fine-tuning or troubleshooting of system performance, if these measures become necessary.
- X. The Contractor shall compensate the Government for retesting and/or troubleshooting time required by the Commissioning Consultant when the Contractor's systems do not meet specified performance and are not ready for commissioning. Back-charge Contractors as necessary to collect reimbursement for Commissioning Consultant compensation.
- Y. Review operating and maintenance data for verification, organization, distribution, and conformance to requirement of the Contract Documents.
- Z. Submit complete operation and maintenance information and as-built drawings to the Commissioning Consultant for compliance review of the requirement of the Contract Documents. Incorporate changes and recommendations provided by the commissioning Consultant into the
- AA. Provide all documentation of training for the specified systems.
- BB. Provide all proprietary test equipment required to test all the systems and equipment in this project. The Contractor shall provide all necessary tools, lifts, ladders, access, PPE, and other equipment required for the Commissioning Consultant to witness Functional Performance Testing.
- CC. The Commissioning Field Notebook will be stored in the Contractors field trailer and will be managed by the Contractor. The Contractor shall confirm in writing to the Commissioning Consultant that systems are complete, functional and the appropriate subcontractors have completed the specified tasks and signed off all pre function documentation.

1.6 DUTIES OF COMMISSIONING CONSULTANT

- A. Develop Commissioning plan at the construction phase.
- B. Develop Functional Test Procedures from Contract Documents and final equipment submittals including narrative sequences of operation, control diagrams and software code for execution with the assistance of Contractor staff as required.
- C. Review the Contractor's submittals relative to the systems and assemblies. Provide comments on the submittals during the same timeframe as the architect / engineer's review. Architect / Engineer has final decision on incorporating comments by the Commissioning Consultant. CM COTR formally incorporates the response to the General Contractor.

- D. Perform site observations to follow installation progress and to verify system installation quality and readiness for testing.
- E. Observe the start-up activities and initial testing of selected equipment and systems as required and review Contractor's start-up documentation.
- F. Observe or review documentation of validation activities including Proper test and balance activities, rotating equipment drive alignment, vibration testing, acoustical testing, electrical testing, and functional tests for normal and off-normal operating sequences.
- G. Review submittal of all required pre-functional and start-up documentation provided by the General Contractor for completeness and reasonableness. This includes installation documentation, start-up documentation, point-to-point checklists, and preliminary TAB report, prior to initiation of functional testing.
- H. Witness a random selection of TAB readings (10%) performed by the TAB contractor. Coordinate with Division 23 and 25 project specifications. This witnessing activity is during the execution of regular TAB activities.
- I. TAB verification to be a separate activity, occurring prior to the final Functional Performance Testing activities.
- J. Assist with scheduling, direct, and witness complete functional testing as defined in the Commissioning Plan and Functional Test Procedures. All testing to be performed and verified by the General Contractor and documented by the Commissioning Consultant.
- K. Witness and verify satisfactory completion of equipment and system tests and inter-systems functional performance tests.
- L. Conduct commissioning meetings and distribute minutes of those meetings to all attendees.
- M. Provide site observation, functional tests, or other project reports in a timely manner.
- N. Document inconsistencies or deficiencies in system operations and system compliance. System deficiencies shall be forwarded to the CM COTR and documented in the Resolution Log.
- O. Coordinate via the General Contractor participation of Government's personnel with equipment, component and systems performance verification and participation in required training.
- P. When commissioning has been successfully completed, recommend acceptance to the Smithsonian Institution, and provide suggestions for those systems not performing as expected.
- Q. Once all functional tests are successfully completed and all outstanding issues resolved, the Commissioning Consultant will provide the Smithsonian Institution with a Final Commissioning Report of all commissioning activities that occurred during the project.
- R. Provide technically qualified personnel when scheduled.
- S. The Commissioning Consultant will formally communicate with the Contractor via approved project channels. It is expected, however, that informal communication and coordination will be conducted directly with the subcontractors; records of all contacts will be sent to the Architect through the normal channels.
- T. The Commissioning Consultant is not authorized to release, revoke, alter or expand requirements of Contract Documents, to approve or accept any portion of the work or to perform any duties of the Contractor.

1.7 COMMISSIONING PLAN

- A. The Commissioning Plan is a tool through which the commissioning process is described and incorporates the

Construction Manager COTR, Architect, Contractor, and Commissioning Authority roles relative to the commissioning process. Commissioning team members are all contractors, subcontractors, and design professionals whose participation is of benefit in the delivery of a fully functioning building to the Government. The plan shall describe the communication, authority, and responsibility of commissioning team members. The Commissioning Plan will include the following:

1. The purpose of commissioning.
2. Detail the commissioning process.
3. Commissioning team members' responsibilities.
4. Describe Pre-functional Construction Checklist Procedures.
5. Provide guidelines for acceptance of each piece of equipment or system.
6. Systems to be commissioned.
7. Provide a .pdf copy of entire completed Commissioning Field Notebook to Commissioning Consultant at conclusion of project for use in developing final Commissioning Report, prepared by the Commissioning Consultant.

1.8 SYSTEMS TO BE COMMISSIONED

- A. Systems and Equipment to Be Functionally Tested: The system features are to be functionally tested, and other building features will be evaluated for installation quality during construction. The functional performance testing will include the following systems and equipment.

1. Mechanical Systems:

- a. Ductless split system units (indoor and outdoor units)
- b. Pumps
- c. Fans
- d. Unit heaters (all types)
- e. ATC dampers in OA intake and exhaust connections
- f. Radiant floor manifolds
- g. Humidifiers
- h. Boilers
- i. Automatic glycol feeder
- j. Condensate pumps (electric & pressure powered)
- k. Building automation system

2. Electrical Systems:

- a. Variable Frequency Controllers
- b. Lighting Control System

1.9 COMMISSIONING ACTIVITIES

- A. The Commissioning Fragnet Schedule: This schedule defines the milestones and conditions that must be achieved before system testing and other commissioning activities can commence. The schedule also includes the expected duration of the various tasks so that the commissioning process can be incorporated into the overall construction schedule.
- B. Preparation for Testing: To prepare for the system performance testing, the Commissioning Consultant will examine the design and Construction Documents, develop with appropriate Contractors Pre-functional Construction Checklists of construction responsibilities that must be completed prior to testing and develop detailed Functional Test Procedures and data forms. Using the Pre-functional Construction Checklists, the Contractor must verify that the systems they install comply with the Construction Documents and are fully functional. Commissioning is not intended to be a testing or inspection function that replaces any of the

Contractors' obligations for testing and proof of performance. Functional testing will only begin when the appropriate subcontractors' complete checklists, initialed, signed and returned to the Commissioning Consultant, the TAB process is complete for both air and water balancing, and the controls are completed, and all control loops properly tuned.

- C. Functional Testing: experienced and qualified technicians of the Contractor(s) perform Functional testing, responsible for installation as facilitated by the Commissioning Consultant and may be observed by other members of the commissioning team including the Owner. Functional testing will verify proper sequencing, operation and performance of installed equipment and systems under realistic operating conditions. The functional testing will follow with written Functional Test Procedures with test results documented for permanent record.
- D. Documentation: In addition to the Pre-functional Construction Checklists and Functional Test Procedures, written documentation will be maintained for all other commissioning activities. Project communication reports shall be issued by the Commissioning Authority to the Contractor and key members of the commissioning team to document apparent deficiencies identified during examination of design and construction documents, daily activities on-site, construction deficiencies and successful or unsuccessful functional test results. At the end of the commissioning process, all documentation will be assembled and summarized in the Final Commissioning Report.
- E. Deficiency Resolution: When an Issues Log, Resolution Log or Field Report is issued to address an identified deficiency, the Contractor shall forward the reports to the appropriate parties to initiate corrective action in an expeditious manner. The designer is relied on for supplemental instructions or design modifications and issuance of final design details and the Contractors are relied on for implementation of that design. Change orders must be issued through proper contract channels.

1.10 FUNCTIONAL TEST PROCEDURES

- A. The Functional Test Procedures include, but are not limited to, the following:
 1. Verification of testing, adjusting and balancing performance.
 2. Verification of all equipment's ability to perform to the design intent.
 3. Verification of the performance of sub-systems consisting of combinations of equipment (e.g., refrigeration cycle, pumps, and interconnecting piping).
 4. Verification of the performance of the automatic controls in all seasonal modes.
 5. Verification of the performance of the HVAC system as a whole.
 6. Verification of the performance of all life safety devices and systems that interface with the HVAC systems. Commissioning of life safety systems by the Commissioning Authority shall be limited to the fire alarm interface with the HVAC systems.

PART 2 - PRODUCTS (NOT USED) PART 3 -

EXECUTION

3.1 GENERAL

- A. Operating equipment and systems shall be tested in the presence of Government's Commissioning Consultant and Project Officer (Construction Manager COTR) to demonstrate compliance with specified requirements.
 1. Notify COTR, in writing, fourteen (14) days prior to tests, twenty-one (21) days prior if a utility shutdown is required, scheduled under requirements of this Section.
 2. Testing shall be conducted under specified design operating conditions as recommended or approved by construction Manager COTR and Architect.

- B. The Functional Performance Testing shall be completed by the Contractor as a requirement of Substantial Completion. The acceptance of Functional Performance Test by Construction Manager COTR is a requirement of Final Completion.
- C. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each sub-system, followed by entire system, followed by interaction with other major systems.
- D. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing contractor. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Consultant in the commissioning process.
- E. Acceptance Documentation: A copy of the functional performance tests results shall be necessary acceptance documentation along with other specified requirements. Documentation must be signed and dated.

3.2 ACCEPTANCE PROCEDURES

- A. Prior to functional performance testing of each system, the Commissioning Consultant shall observe and verify that the physical installation of components and systems being tested is substantially installed in accordance with the Contract Documents.
- B. Contractor's Tests:
 - 1. System shall be checked for proper installation, shall be adjusted, and calibrated to verify that it is ready to function as specified.
 - 2. All system elements shall be checked to verify that they have been installed properly and that all connections have been made correctly.
 - 3. All discrete elements and sub-systems shall be adjusted and checked for proper operation.
 - 4. Start-up and operational tests shall be complete, with all required Pre-functional Construction Checklists signed and submitted for review by Commissioning Consultant within five (5) days of each activity, prior to starting functional performance testing.
- C. Smithsonian Institution witnessed Functional Tests:
 - 1. Objective of these tests is to demonstrate that system is operating and complying with specified performance requirements.
 - 2. Smithsonian Institution witnessed functional performance tests shall be performed on complete system. Each function shall be demonstrated to satisfaction of the Architect / Engineer through the CM COTR and Smithsonian Institution's Commissioning Consultant on paragraph-by-paragraph basis of Commissioning Consultant's written test procedure, developed to demonstrate conformance to requirements of the Specifications.
 - 3. Functional performance tests shall be witnessed and endorsed by the Commissioning Consultant upon satisfactory completion.
 - 4. Actual testing program shall be conducted in accordance with prior approved procedures and shall be documented as required herein.
 - 5. Contractor shall notify Architect and Construction Manager COTR at least two (2) weeks prior to date of functional performance tests.
- D. The functional performance testing process shall be accomplished for all equipment, sub-systems, systems, and system interfaces. The order of functional performance testing shall be reflected in the Commissioning Fragnet Schedule. All must be tested for acceptance and there shall be a separate checklist for each to ensure documentation specific to each is complete.

- E. Each system shall be operated through all modes of system operation (e.g., seasonal, occupied, unoccupied, warm-up, cool-down, etc., as applicable) including every individual interlock and conditional control logic, all control sequences, both full-load and part-load conditions and simulation of all abnormal conditions for which there is a specified system or controls response. The warm-up and cool-down test shall be a performance test, as applicable.
- F. Temporary upsets of systems, such as distribution faults, control loss, set-point change, equilibrium upset and component failure, shall be imposed at different operation loads to determine system stability and recovery time.
- G. When the functional performance of all individual systems has been proven, the interface or coordinated responses between systems shall be checked. The systems involved may be within

the overall HVAC work or they may involve other systems, such as emergency systems for life safety.
- H. Corrective Measures: If acceptable performance cannot be achieved, the cause of the deficiency will be identified. If it is determined that the deficiency was caused by the system or component not being installed per the manufacturer's recommendations or Contract Documents, the necessary corrective measures shall be conducted by the General Contractor. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process should be repeated until acceptable performance is achieved. The Contractor will be allowed one retest after initial testing of the equipment. If the retest fails, the Contractor shall be financially responsible, at standard rates, to reimburse the Commissioning Consultant for the additional time taken to achieve acceptable performance.

3.3 TRAINING AND INSTRUCTION

- A. Training and instruction of Government personnel is a part of the commissioning process and essential for the proper operation of the facility. The contractors and vendors providing the training will complete training plans and submit to the Commissioning Consultant for review and approval in conjunction with the COTR.

3.4 SEASONAL COMMISSIONING AND OCCUPANCY VARIATIONS

- A. Seasonal commissioning pertains to testing under full-load conditions during peak heating and peak cooling seasons, as well as part-load conditions in the spring and fall. Initial commissioning will be done as soon as contract work is completed, regardless of season. Subsequent commissioning may be undertaken at any time thereafter to ascertain adequate performance during the different seasons.
- B. All equipment and systems will be tested and commissioned in a peak season to observe full-load performance. Heating equipment will be tested during winter design conditions. Cooling equipment will be tested during summer design conditions, with a fully occupied building. Each Contractor and supplier will be responsible to participate in the initial and the alternate peak season test of the systems required demonstrating performance.
- C. Subsequent commissioning may be required under conditions of minimum and/or maximum occupancy or use. All equipment and systems affected by occupancy variations will be tested and commissioned at the minimum and peak loads to observe system performance. Each Contractor and supplier will be responsible to participate in the occupancy sensitive testing of systems to provide verification of adequate performance.
- D. Commissioning team including contractor, subcontractors, commissioning personnel and COTR shall meet at site roughly ten months after Substantial Completion to review any system issues, and correct any operational concerns covered by warranty. Commissioning Consultant shall lead this site meeting and shall summarize findings in a site report.

3.5 SCHEDULE

- A. The schedule includes the probable expected sequence and duration for the various tasks, so that the commissioning process can be integrated with the general construction schedule and refined over the course of the project. Actual sequencing and durations shall be by the General Contractor and Sub-Contractors, coordinated with the Commissioning Consultant.

Milestone	Duration	Successor	Predecessor
Commissioning Kick off Mtg.	1 day	All contractors on board including Controls and TAB	Before major MEP installation
Review equipment submittals	2 weeks	After receipt of submittals	Before ordering or installation
Develop Pre-functional Construction Checklists	4 weeks	After equipment submittal review and after receipt of O&M literature	Before MEP installation
Walk contractors through Pre-functional Construction Checklists	5 days	After development of Pre-Functional Checklist documentation	Before MEP installation
Write Functional Tests	3 to 5 weeks	After controls submittal review	3 weeks prior to functional testing
Submit Functional Tests for review by COTR and Contractors	1 week	After development of Functional Tests	Before Functional testing
Complete Pre-functional Construction Checklists (contractor task)	Ongoing	During installation, startup, and test, adjust and balance	Before TAB Backcheck and functional testing
Site Observations (CxA)	Ongoing	After majority of MEP installation	Before TAB Backcheck and functional testing
Test, Adjust and Balance (Contractor task)	See CPM schedule	After Start-up and Pre-functional Construction checks. All walls, windows, doors, ceilings must be installed.	Before TAB Backcheck
Test, Adjust and Balance Backcheck (10%)	1 week	After Start-up and receipt of completed Pre-functional Construction Checklists from contractors	Before functional testing
Functional Testing	2 months postponed if needed for slab heating in winter.	After TAB Backcheck and receipt of completed Pre-functional Construction Checklist have been completed by contractors	Before Government occupancy
Issues Resolution	2 weeks	After Functional Testing	Before Government occupancy
Final Commissioning Documentation Submittal	2 weeks	After resolution of issues log	2 weeks after resolution of issues log

END OF SECTION 01 91 13

SECTION 02 4116 - STRUCTURE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Demolition and removal of buildings and site improvements.
 - 2. Abandoning in-place Removing below-grade construction.
 - 3. Disconnecting, capping or sealing, and abandoning in-place removing site utilities.
 - 4. Salvaging items for reuse by Owner.
- B. Related Requirements:
 - 1. Section 01 0000 "Supplementary Conditions for Construction".
 - 2. Section 01 1000 "Summary" for use of the premises and phasing requirements.
 - 3. Section 02 4119 "Selective Structure Demolition" for partial demolition of buildings, structures, and site improvements.
 - 4. Section 31 1000 "Site Clearing" for site clearing and removal of above- and below-grade site improvements not part of building demolition.

1.2 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged.
- B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner ready for reuse. Include fasteners or brackets needed for reattachment elsewhere.

1.3 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.
 - 1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

1.4 PREINSTALLATION MEETINGS

- A. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be demolished.
 - 2. Review structural load limitations of existing structures.
 - 3. Review and finalize building demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review and finalize protection requirements.
 - 5. Review procedures for noise control and dust control.
 - 6. Review procedures for protection of adjacent buildings.
 - 7. Review items to be salvaged and returned to Owner.

1.5 INFORMATIONAL SUBMITTALS

- A. Engineering Survey: Submit engineering survey of condition of building.
- B. Proposed Protection Measures: Submit informational report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection, for dust control and, for noise control. Indicate proposed locations and construction of barriers.
 - 1. Adjacent Buildings: Detail special measures proposed to protect adjacent buildings to remain[including means of egress from those buildings].
- C. Schedule of Building Demolition Activities: Indicate the following:
 - 1. Detailed sequence of demolition work, with starting and ending dates for each activity.
 - 2. Temporary interruption of utility services.
 - 3. Shutoff and capping or re-routing of utility services.
- D. Inventory: Submit a list of items to be removed and salvaged and deliver to Owner prior to start of demolition.
- E. Predemolition Photographs: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by demolition operations. Comply with Section 01 3233 "Photographic Documentation." Submit before the Work begins.
- F. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

1.6 CLOSEOUT SUBMITTALS

- A. Inventory: Submit a list of items that have been removed and salvaged.

1.7 QUALITY ASSURANCE

- A. Refrigerant Recovery Technician Qualifications: Certified by EPA-approved certification program.
- B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- C. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.
- D. Predemolition Conference: Conduct conference at Project site.
 - 1. Inspect and discuss condition of construction to be demolished.
 - 2. Review structural load limitations of existing structures.
 - 3. Review and finalize building demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
 - 4. Review and finalize protection requirements.

5. Review procedures for noise control and dust control.
6. Review procedures for protection of adjacent buildings.
7. Review items to be salvaged and returned to Owner.

1.8 FIELD CONDITIONS

- A. Buildings to be demolished will be vacated and their use discontinued before start of the Work.
- B. Buildings immediately adjacent to demolition area will be occupied. Conduct building demolition so operations of occupied buildings will not be disrupted.
 1. Provide not less than 72 hours' notice of activities that will affect operations of adjacent occupied buildings.
 2. Maintain access to existing walkways, exits, and other facilities used by occupants of adjacent buildings.
 - a. Do not close or obstruct walkways, exits, or other facilities used by occupants of adjacent buildings without written permission from authorities having jurisdiction.
- C. Owner assumes no responsibility for buildings and structures to be demolished.
 1. Conditions existing at time of inspection for bidding purpose will be maintained by Owner as far as practical.
- D. Hazardous Materials: It is not expected that hazardous materials will be encountered in the Work.
 1. Hazardous materials will be removed by Owner before start of the Work.
 2. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.
- E. On-site storage or sale of removed items or materials is not permitted.

1.9 COORDINATION

- A. Arrange demolition schedule so as not to interfere with Owner's on-site operations or operations of adjacent occupied buildings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.
- B. Standards: Comply with ANSI/ASSE A10.6 and NFPA 241.

2.2 SOIL MATERIALS

- A. Satisfactory Soils: Comply with requirements in Section 31 2000 "Earth Moving."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that utilities have been disconnected and capped before starting demolition operations.
- B. Review Project Record Documents of existing construction provided by Owner. Owner does not guarantee that existing conditions are same as those indicated in Project Record Documents.
- C. Inventory and record the condition of items to be removed and salvaged. Provide photographs of conditions that might be misconstrued as damage caused by salvage operations. Comply with Section 01 3233 "Photographic Documentation."
- D. Engage a professional engineer to perform an engineering survey of condition of building to determine whether removing any element might result in structural deficiency or unplanned collapse of any portion of structure or adjacent structures during building demolition operations.
 - 1. Steel Tendons: Locate tensioned steel tendons and include recommendations for de-tensioning.
- E. Verify that hazardous materials have been remediated before proceeding with building demolition operations.
- F. Inventory and record the condition of items to be removed and salvaged.

3.2 PREPARATION

- A. Refrigerant: Remove refrigerant from mechanical equipment according to 40 CFR 82 and regulations of authorities having jurisdiction before starting demolition.
- B. Existing Utilities: Locate, identify, disconnect, and seal or cap off indicated utilities serving buildings and structures to be demolished.
 - 1. Owner will arrange to shut off indicated utilities when requested by Contractor.
 - 2. If removal, relocation, or abandonment of utility services will affect adjacent occupied buildings, then provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.
 - 3. Cut off pipe or conduit a minimum of 24 inches (610 mm) below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing according to requirements of authorities having jurisdiction.
- C. Temporary Shoring: Provide and maintain interior and exterior shoring, bracing, or structural support to preserve stability and prevent unexpected movement or collapse of construction being demolished.
 - 1. Strengthen or add new supports when required during progress of demolition.
- D. Salvaged Items: Comply with the following:
 - 1. Clean salvaged items of dirt and demolition debris.
 - 2. Pack or crate items after cleaning. Identify contents of containers.
 - 3. Store items in a secure area until delivery to Owner.
 - 4. Transport items to storage area designated by Owner.
 - 5. Protect items from damage during transport and storage.

3.3 UTILITY SERVICES AND MECHANICAL/ELECTRICAL SYSTEMS

- A. Existing Utilities to be Disconnected: Locate, identify, disconnect, and seal or cap off utilities serving buildings and structures to be demolished.
 - 1. Owner will arrange to shut off utilities when requested by Contractor.
 - 2. Arrange to shut off utilities with utility companies.
 - 3. If removal, relocation, or abandonment of utility services will affect adjacent occupied buildings, then provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.
 - 4. Cut off pipe or conduit a minimum of 24 inches (610 mm) below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing according to requirements of authorities having jurisdiction.
 - 5. Do not start demolition work until utility disconnecting and sealing have been completed and verified in writing.

3.4 PROTECTION

- A. Existing Facilities: Protect adjacent walkways, loading docks, building entries, and other building facilities during demolition operations. Maintain exits from existing buildings.
- B. Temporary Shoring: Provide and maintain interior and exterior shoring, bracing, or structural support to preserve stability and prevent unexpected movement or collapse of construction being demolished.
 - 1. Strengthen or add new supports when required during progress of demolition.
- C. Existing Utilities to Remain: Maintain utility services to remain and protect from damage during demolition operations.
 - 1. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by Owner and authorities having jurisdiction.
 - 2. Provide temporary services during interruptions to existing utilities, as acceptable to Owner and authorities having jurisdiction.
 - a. Provide at least 72 hours' notice to occupants of affected buildings if shutdown of service is required during changeover.
- D. Temporary Protection: Erect temporary protection, such as walks, fences, railings, canopies, and covered passageways, where required by authorities having jurisdiction and as indicated. Comply with requirements in Section 01 5000 "Temporary Facilities and Controls."
 - 1. Protect adjacent buildings and facilities from damage due to demolition activities.
 - 2. Protect existing site improvements, appurtenances, and landscaping to remain.
 - 3. Erect a plainly visible fence around drip line of individual trees or around perimeter drip line of groups of trees to remain.
 - 4. Provide temporary barricades and other protection required to prevent injury to people and damage to adjacent buildings and facilities to remain.
 - 5. Provide protection to ensure safe passage of people around building demolition area and to and from occupied portions of adjacent buildings and structures.
 - 6. Protect walls, windows, roofs, and other adjacent exterior construction that are to remain and that are exposed to building demolition operations.
 - 7. Erect and maintain dustproof partitions and temporary enclosures to limit dust, noise, and dirt migration to occupied portions of adjacent buildings.

- E. Remove temporary barriers and protections where hazards no longer exist. Where open excavations or other hazardous conditions remain, leave temporary barriers and protections in place.

3.5 DEMOLITION, GENERAL

- A. General: Demolish indicated buildings and site improvements completely. Use methods required to complete the Work within limitations of governing regulations and as follows:
 - 1. Do not use cutting torches until work area is cleared of flammable materials. Maintain portable fire-suppression devices during flame-cutting operations.
 - 2. Maintain fire watch during and for at least 2 hours after flame cutting operations.
 - 3. Maintain adequate ventilation when using cutting torches.
 - 4. Locate building demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.
- B. Engineering Surveys: During demolition, perform surveys to detect hazards that may result from building demolition activities.
- C. Site Access and Temporary Controls: Conduct building demolition and debris-removal operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.
 - 1. Do not close or obstruct streets, walks, walkways, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
 - 2. Use water mist and other suitable methods to limit spread of dust and dirt. Comply with governing environmental-protection regulations. Do not use water when it may damage adjacent construction or create hazardous or objectionable conditions, such as ice, flooding, and pollution.
- D. Explosives: Use of explosives is not permitted.

3.6 DEMOLITION BY MECHANICAL MEANS

- A. Proceed with demolition of structural framing members systematically, from higher to lower level. Complete building demolition operations above each floor or tier before disturbing supporting members on the next lower level.
- B. Remove debris from elevated portions of the building by chute, hoist, or other device that will convey debris to grade level in a controlled descent.
 - 1. Remove structural framing members and lower to ground by method suitable to minimize ground impact and dust generation.
- C. Salvage: Items to be removed and salvaged are indicated on Drawings.
- D. Below-Grade Construction: Demolish foundation walls and other below-grade construction that are within footprint of new construction and extending 5 feet (1.5 m) outside footprint indicated for new construction. Abandon below-grade construction outside this area.
 - 1. Remove below-grade construction, including basements, foundation walls, and footings, to depths indicated.

- E. Existing Utilities: Demolish and remove existing utilities and below-grade utility structures.
 - 1. Piping: Disconnect piping at unions, flanges, valves, or fittings.
 - 2. Wiring Ducts: Disassemble into unit lengths and remove plug-in and disconnecting devices.

3.7 SITE RESTORATION

- A. Below-Grade Areas: Rough grade below-grade areas ready for further excavation or new construction.
- B. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

3.8 REPAIRS

- A. Promptly repair damage to adjacent buildings caused by demolition operations.

3.9 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolition waste materials from Project site and recycle or dispose of them according to Section 01 7419 "Construction Waste Management and Disposal."
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Do not burn demolished materials.

3.10 CLEANING

- A. Clean adjacent structures and improvements of dust, dirt, and debris caused by building demolition operations. Return adjacent areas to condition existing before building demolition operations began.
 - 1. Clean roadways of debris caused by debris transport.

END OF SECTION

SECTION 02 4119 – SELECTIVE DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Sections includes the following:
 - 1. Removing below grade construction.
- B. Disconnecting, capping or sealing, and removing site utilities. Removing existing elements if removal is necessary to accommodate the new design. These elements include, but are not limited to:
 - 1. Utilities including pipes, ducts, and conduits

1.2 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged.
- B. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged.

1.3 SUBMITTALS

- A. Proposed Environmental-Protection, Dust-Control and Noise-Control Measures: Submit statement or drawing that indicates the measures proposed for use, proposed locations, and proposed time frame for their operation. Identify options if proposed measures are later determined to be inadequate.
- B. Schedule of Site Demolition Activities: Indicate the following:
 - 1. Detailed sequence of demolition and removal work, with starting and ending dates for each activity.
 - 2. Interruption of utility services.
 - 3. Coordination for shutoff, capping, and continuation of utility services.

1.4 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Health Hazards:
 - a. Whenever construction operations could result in worker contact with hazardous materials, follow recommendations of an American Board of Industrial Hygiene Certified Industrial Hygienist (CIH) employed by Contractor.
 - b. Existing Asbestos and Asbestos-Containing Materials: Comply with 29 CFR 1926.1101; complete removal is required.
 - c. Existing Lead-Based Paint: Comply with 29 CFR 1926.62; either removal or recoating is acceptable.

1.5 PROJECT CONDITIONS

- A. Storage or sale of removed items or materials on site is not permitted.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Survey existing conditions and correlate with requirements indicated to determine extent of utility demolition required.
- B. Review Project Record Documents of existing construction provided by SI and NZP. SI and NZP does not guarantee the existing conditions are the same as those indicated in Project Record Documents.
- C. When unanticipated mechanical, electrical, or structural elements are encountered, investigate, and measure the nature and extent of the element.
- D. Verify that hazardous materials have been remediated before proceeding with utility demolition operations.

3.2 PREPARATION

- A. Existing Utilities: Locate, identify, and protect all utilities within the limits of disturbance, disconnect, and seal or cap off indicated utilities serving buildings and structures to be demolished.
 - 1. Arrange to shut off indicated utilities with Contracting Officer Technical Representative (COTR).
 - 2. If utility services are required to be removed or relocated, before proceeding with building demolition provide temporary utilities that bypass buildings and structures to be demolished and that maintain continuity of service to other buildings and structures.
 - 3. Cut off pipe or conduit a minimum of 2-feet below grade. Cap, valve, or plug and seal remaining portion of pipe or conduit after bypassing.

3.3 PROTECTION

- A. Existing Utilities: Maintain utility services indicated to remain and protect them against damage during demolition operations.
 - 1. Do not interrupt existing utilities serving adjacent occupied or operating facilities unless authorized in writing by COTR.
 - 2. Provide temporary services during interruption to existing utilities, as acceptable to COTR.
 - 3. Provide at least 72 hours' notice to COTR if shutdown of service is required during changeover.

3.4 DEMOLITION

- A. Engineering Surveys: Perform surveys as the Work progresses to detect hazards that may result from utility demolition activities.
- B. Existing Utilities: Demolish existing utilities and below grade utility structures as indicated.
- C. Explosives: Use of explosives is not permitted.

3.5 SITE RESTORATION

- A. Below-Grade Areas: Rough grade below-grade areas ready for further excavation or new construction.
- B. Site Grading: Uniformly rough grade area of demolished construction to a smooth surface, free from irregular surface changes. Provide a smooth transition between adjacent existing grades and new grades.

3.6 REPAIRS

- A. General: Promptly repair damage to adjacent construction caused by utility demolition.
- B. Where repairs to existing surfaces are required, patch to produce surfaces suitable for a new materials.
- C. Restore exposed finishes of patched areas and extend restoration into adjoining construction in a manner that eliminates evidence of patching and refining.

3.7 DISPOSAL OF DEMOLISHED MATERIALS

- A. Remove demolished materials from Project site and legally dispose of them.
 - 1. Do not allow demolished materials to accumulate on-site.
 - 2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
- B. Burning: Do not burn demolished materials.
- C. Disposal: Transport demolished materials off-site and legally dispose of them.

3.8 CLEANING

Clean adjacent structures and improvements of dust, dirt, and debris caused by demolition operations. Return adjacent areas to existing condition before demolition operations began.

END OF SECTION

SECTION 03 3000 – CAST IN PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to the work of this Section.

1.2 SUMMARY

- A. Section includes but is not limited to the following as shown on the drawings and as specified herein:
 - 1. Foundation systems including footings, pile caps, piles, walls, beams, piers, pilasters, pits and similar concrete.
 - 2. Slabs on grade.
 - 3. Structural slabs on grade.
 - 4. Structural slabs on metal deck.
 - 5. Cast-in-place slabs, beams, walls, and columns.
 - 6. Topping slabs.
 - 7. Furnishing and installing all required anchors and inserts.
 - 8. Placing in the forms all inserts, anchors, anchor bolts, bearing plates and the like furnished by other trades for casting into the concrete and cleaning of same after stripping of forms.
 - 9. Protection of all inserts, anchors, hangers, sleeves and supports furnished and set by others for the attachment of other work to the concrete, or required to permit the passage of other work through the concrete.
 - 10. Supply, fabricate and place all required reinforcing bars, mesh and other reinforcement for concrete where shown, called for, and/or required complete with proper supporting devices.
 - 11. Erection and removal of all formwork required to properly complete the work.
 - 12. Finishing of all concrete work as hereinafter specified.
 - 13. Curing and protection of all concrete work.
 - 14. Site concrete consisting of curbs, walls, pads, boxes and the like as shown on the drawings.
 - 15. Floor sealers and dust-proofing of all areas exposed and/or covered with carpet.
 - 16. Cutting, patching, grouting, repairing and pointing up as required.
 - 17. Vapor barrier system below slabs on grade.
 - 18. Under slab drainage course.
 - 19. Dewatering.
 - 20. Waterproofing.
 - 21. Equipment pads as required.
 - 22. All other work and materials as may be reasonably inferred and needed to make the work of this section complete.
 - 23. Waste Management
- B. Related Requirements:
 - 1. Division 01 Section “Construction Waste Management and Disposal”
 - 2. Division 04 Section “Unit Masonry”
 - 3. Division 05 Section “Structural Steel”
 - 4. Division 05 Section “Metal Deck”
 - 5. Division 05 Section “Metal Fabrications”

6. Division 06 Section "Rough Carpentry"
7. Division 07 Section "Waterproofing"
8. Division 07 Section "Joint Sealants"
9. Division 07 Section "Expansion Joint Cover Assemblies"
10. Division 31 Section "Dewatering"

1.3 SUSTAINABLE DESIGN REQUIREMENTS

- A. The Contractor is to efficiently use resources and energy while executing the Work of this Section. Resource efficient aspects to be considered in completing this Project include the use of techniques that minimize waste generation, reuse of construction materials on site where possible, and recycling of waste generated during the construction process.
- B. Performance Requirements: The following criteria are required for the products included in this section
 1. Preference shall be given to cast-in-place concrete containing raw materials harvested or extracted within 500 miles of the project site.
 2. All reinforcing steel, steel anchors, welded wire reinforcement, and other steel items required by the work of this section shall contain a minimum of 50% (combined) pre-consumer/post-consumer recycled content.

1.4 SUBMITTALS

- A. Product Data: Submit data for proprietary materials and items, including the following:
 1. Reinforcement.
 2. Supports for reinforcement.
 3. Forming accessories.
 4. Admixtures.
 5. Patching compounds.
 6. Waterstops.
 7. Joint systems.
 8. Curing compounds.
 9. Dry-shake finish materials.
 10. Mechanical splice couplers.
 11. Others items as requested by Architect.
- B. Shop Drawings, Reinforcement: Submit original shop drawings for fabrication, bending, and placement of concrete reinforcement. Comply with ACI 315 "Details and Detailing of Concrete Reinforcement" showing bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welded splices, tie spacing, hoop spacing, and supports for concrete reinforcement. Include special reinforcement required for openings through concrete structures. The shop drawings shall be prepared only by competent detailers, checked by the contractor prior to submission.
 1. The shop drawings shall show construction, contraction and isolation joint locations and the added reinforcement required at same.
 2. Obtain and coordinate information for sleeves, openings, and conduits in concrete, which are required for the work of other trades. Make coordinated drawings showing size and location of all openings, sleeves, and conduits and incorporate this information on the reinforcing drawings.

3. Only those splices indicated on the approved shop drawings will be permitted.
 4. Provide elevations of all foundation walls and other structural elements to a minimum 1/4" scale.
 5. For structural thermal break connection system, indicate general configuration, insulation dimensions, tension bars, compression pads, shear bars, and dimensions.
- C. Shop Drawings Formwork: Submit shop drawings for fabrication and erection of specific finished concrete surfaces. Show form construction including jointing, special form joint or reveals, location and pattern of form tie placement, and other items which affect exposed concrete visually. Architect's review is for general architectural applications and features only. Design of formwork for structural stability and efficiency is Contractor's responsibility, prepared by or under the supervision of a qualified professional engineer detailing fabrication, assembly, and support of formwork.
1. Shoring and Reshoring: Indicate proposed schedule and sequence of stripping formwork, shoring removal, and reshoring installation and removal.
- D. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.
1. Location of construction joints is subject to approval of the Architect.
- E. Contraction Joint Layout: Indicate proposed contraction joints required per applicable codes and drawings.
1. Location of contraction joints is subject to approval of the Architect.
- F. The use of the Architect's or Engineer of Record's electronic drawing files as a base for the reinforcement, formwork, and joint layout shop drawings will be permitted at the request of the detailer/designer upon completion and return of the waiver form. The use of the Architect's or Engineer of Record's electronic drawing files as a base for shop drawing details will not be permitted. The detailer/designer will be responsible for compatibility of the files with his hardware or software. The electronic files are not to be considered the contract documents, the design team makes no representation regarding the accuracy or completeness of the electronic files given to detailer/designer and their use will be at the detailer/designer's sole risk and without liability to the design team. The detailer/designer shall remove the project title box and all references to the structural drawings including drawing numbers and structural drawing sections and details. The detailer/designer shall also remove all reference to work not included in the concrete contract.
- G. Scaling of the Architect's or Engineer of Record's drawings is not permitted. This applies to hard paper, electronic, and all other versions.
- H. Samples: Submit samples of materials as requested by Architect, including names, sources and descriptions.
- I. Laboratory Test Reports: Submit laboratory test reports for concrete materials, mix design test and microwave test.
- J. Material Certificates: Provide materials certificates in lieu of materials laboratory test reports when permitted by Architect. Manufacturer and Contractor, certifying that each material item complies with, or exceeds, specified requirements shall sign material certificates. Provide certification from admixture manufacturers that chloride content complies with specification requirements.

- K. Cold Weather and Hot Weather Concreting Procedures: Submit written descriptions of contractor's proposed cold weather and hot weather concreting procedures, when applicable.
- L. Certification that pozzolanic materials conforms to ASTM C 618-01 (noting class C or class F), ASTM C 989 or ASTM C1240.
- M. Certified recycled steel content. Provide cut sheets clearly indicating whether the rebar used meets the minimums for post-consumer OR post-industrial recycled contents. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and if the recycled content is post-consumer or post-industrial.
- N. Formwork: Specify whether reusable, permanent, salvaged or new wood forms are to be used.
- O. Recycled Aggregate: Provide laboratory reports indicating that aggregate conforms to ASTM C33 for structural concrete or ASTM D1241-00 for sub-base material. Provide cut sheets clearly indicating the source, total weight and volume of the recycled aggregate. If aggregate provided is a mix of virgin and recycled aggregates obtain a written affidavit from the manufacturer stating the recycled content percentage
- P. VOC content for curing compounds, sealants and release agents: Provide a cut sheet and a Material Safety Data Sheet (MSDS) for each curing compound, sealant, hardener and release agent used highlighting VOC contents. VOC content must be less than or equal to limits stated under "PRODUCTS".

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified installer who employs on Project personnel qualified as ACI-certified Flatwork Technician and Finisher and a supervisor who is an ACI-certified Concrete Flatwork Technician.
- B. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.4/D 1.4M, "Structural Welding Code - Reinforcing Steel."
- D. Codes and Standards: Comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified:
 - 1. International Building Code, 2024
 - 2. ACI 117 "Standard Specifications for Tolerances for Concrete Construction and Materials and Commentary."
 - 3. ACI 211.1 "Standard Practice for Selecting Proportions for Normal, Heavyweight and mass concrete."
 - 4. ACI 211.2, "Standard Practice for Selecting Proportions for Structural Lightweight Concrete."
 - 5. ACI 214R, "Evaluation of Strength Test Results of Concrete."
 - 6. ACI 232.2R, "Use of Fly Ash in Concrete."
 - 7. ACI 233R, "Guide to Use of Slag Cement in Concrete and Mortar."
 - 8. ACI 234, "Guide for the Use of Silica Fume in Concrete."
 - 9. ACI 301 "Specifications for Structural Concrete."

10. ACI 302.1R "Guide for Concrete Floor and Slab Construction."
 11. ACI 304R, "Guide for Measuring, Mixing, Transporting and Placing Concrete."
 12. ACI 305R "Hot Weather Concreting."
 13. ACI 306R-10 "Guide to Cold Weather Concreting."
 14. ACI 308.1 "Standard Specification for Curing Concrete."
 15. ACI 309R, "Guide for Consolidation of Concrete."
 16. ACI 311.4R, "Guide for Concrete Inspections."
 17. ACI 315, "Details and Detailing of Concrete Reinforcement."
 18. ACI 318 "Building Code Requirements for Structural Concrete and Commentary."
 19. ACI 347 "Guide to Formwork of Concrete."
 20. Concrete Reinforcing Steel Institute, (CRSI) "Manual of Standard Practice."
 21. CRSI-WCRSI, "Placing Reinforcing Bars."
 22. AWS D1.4, "Structural Welding Code Reinforcing Steel."
 23. The ACI Field Reference Manual, SP-15 shall be kept at the job site, and the practices set forth therein shall be strictly adhered to.
 24. ASTM Standards as applicable in the building code of the local jurisdiction and as noted in this specification.
 25. AASHTO T 318, "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying."
- E. Concrete Testing Service: Owner will engage a testing laboratory acceptable to Architect and Engineer of Record to perform material evaluation tests and to design concrete mixes.
- F. Materials and installed work may require testing and retesting at anytime during progress of work. Tests, including retesting of rejected materials for installed work, shall be done at Contractor's expense.
- G. Mockups: Cast concrete slab-on-grade and formed-surface panels to demonstrate typical joints, surface finish, texture, tolerances, floor treatments, and standard of workmanship.
1. Build panel approximately 200 sq. ft. (18.6 sq. m) for slab-on-grade minimum and 100 sq. ft. (9.3 sq. m) for formed surfaces in the location indicated or, if not indicated, as directed by Architect.
 2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- H. Preconstruction Meeting:
1. At least 35 days prior to the start of the concrete construction schedule, the Contractor shall conduct a meeting to review the proposed mix designs and to discuss the required methods and procedures to achieve the required concrete construction. The Contractor shall send a pre-concrete conference agenda to all attendees 20 days prior to the scheduled date of the conference.
 2. The Contractor shall require responsible representatives of every party who is concerned with the concrete work to attend the conference, including but not limited to the following:
 - a. Contractor's superintendent
 - b. Laboratory responsible for the concrete design mix
 - c. Laboratory responsible for field quality control
 - d. Concrete subcontractor
 - e. Ready-mix concrete producer
 - f. Admixture manufacturer(s)
 - g. Concrete pumping equipment manufacturer.

3. Minutes of the meeting shall be recorded, typed and printed by the contractor and distributed by the contractor to all parties concerned within 5 days of the meeting. One copy of the minutes shall also be transmitted to the following for information purposes: Owner or owner's representative, Architect, and Engineer of Record.
4. The minutes shall include a statement by the concrete contractor indicating that the proposed mix design and placing can produce the concrete quality required by these specifications.
5. A minimum of a 4 cubic yard trial mixture containing all required admixtures shall be placed at the job site using the accepted methods of placing, finishing and curing. All applicable tests including slump, strength, water content, air content, permeability, and air content will be performed. This shall occur at least four weeks before actual concreting operations with the proposed mix design begins. The admixture manufacturer(s) and inspectors shall be present. The same testing should be done in the laboratory at the same time for comparison. A test sample should be done for each condition that is to be placed.
6. The Engineer of Record will be present at the conference. The Contractor shall notify the Engineer of Record at least 10 days prior to the scheduled date of the conference.

1.6 PROJECT CONDITIONS

- A. The Contractor, before commencing work, shall examine all adjoining work on which this work is in any way dependent for proper installation and workmanship according to the intent of this specification, and shall report to the Architect or Engineer of Record any condition which prevents this contractor from performing first class work.
- B. Protection of Footings Against Freezing: Cover completed work at footing level with sufficient temporary or permanent cover as required to protect footings and adjacent subgrade against possibility of freezing; maintain cover for time period as necessary.
- C. Protect adjacent finish materials against spatter during concrete placement.
- D. Provide all barricades and safeguards at all pits, holes, shaft and stairway openings, etc., to prevent injury to workmen and others within and about the premises. Also provide all safeguards as required by the Building Code, OSHA, or any other departments having jurisdiction. Take full responsibility for all safety precautions and methods.
- E. Procedure of Work: The contractor shall keep themselves constantly informed as to the progress of the work in the field, materials and workers ready to start work immediately when conditions of preceding work are available or ready, wholly or in part, so as not to delay the progress of building work or to interfere with the progress of work of other contractors, and in any event the contractor shall, within 24 hours after notice from the Owner, proceed with such work as directed to maintain the uninterrupted progress of the work.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage. Avoid damaging coatings on steel reinforcement.
- B. Waterstops: Store waterstops under cover to protect from moisture, sunlight, dirt, oil, and other contaminants.

PART 2 - PRODUCTS**2.1 FORM MATERIALS**

- A. Forms for Exposed Finish Concrete: Unless otherwise indicated, construct of plywood, metal, metal-framed plywood faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on drawings. Provide form material with sufficient strength and thickness to withstand pressure of newly placed concrete without bow or deflection.
1. Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood", Class I, Exterior Grade or better mill oiled and edge-sealed, with each piece bearing legible inspection trademark.
- B. Forms for Unexposed Finish Concrete: Plywood, lumber, metal, or other acceptable material. Preference shall go to salvaged or re-used Dimensional Lumber. Provide lumber dressed on at least 2 edges and one side for tight fit.
- C. Sustainability Requirements For Wood Used For Formwork
1. New Dimensional Lumber for Formwork: Provide wood certification documentation from the manufacturer/distributor, declaring conformance with Forest Stewardship Council (FSC) guidelines for certified wood building components. The following independent certification organizations are accredited by the FSC and provide the manufacturer/distributor with documentation:
 - a. Scientific Certification Systems, Inc..
 - b. Smart Wood Certification Program: Rainforest Alliance
 2. Salvaged or re-used Dimensional Lumber for Formwork: Provide documentation certifying products are from salvaged wood sources. Provide grading certificate for structural applications. For wood salvage wood resources see GreenSpec.
 3. If new dimensional Lumber is neither Certified nor salvaged: select regionally grown lumber with the lowest grade that meets performance requirements.
- D. Form Coatings: Provide VOC compliant commercial formulation form-coating compounds that will not bond with, stain nor adversely affect concrete surfaces, and will not impair subsequent treatments of concrete surfaces. Use biodegradable form release agent listed below or equivalent made from soy or rapeseed oil.
- | | |
|----------------------|---------------------------------|
| 1. "Clean Strip JEF" | Dayton Superior |
| 2. "Bio-Form" | M Chem Solutions |
| 3. "Duogard II" | W. R. Meadows, Inc. |
| 4. "Atlas Bio-Guard" | Atlas Construction Supply, Inc. |
- E. Forms for Cylindrical Columns, Pedestals, and Supports: Metal, glass-fiber-reinforced plastic, paper, or fiber tubes that produce surfaces not exceeding specified formwork surface class.
1. Provide forms with sufficient wall thickness to resist plastic concrete loads without detrimental deformation.
- F. Void Forms: Biodegradable paper surface, treated for moisture resistance, structurally sufficient to support weight of plastic concrete and other superimposed loads.

- G. Form Ties: Form ties and spreaders: prefabricated assemblies by Richmond; Superior, Dayton or approved equal. Wire ties shall not be used. Ties for foundation work shall be of snap design with removal cones and water seal washer.
1. Furnish units that will leave no corrodible metal closer than 1 inch (25 mm) to the plane of exposed concrete surface.
 2. Furnish ties that, when removed, will leave holes no larger than 1 (25 mm) inch in diameter in concrete surface.
 3. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

2.2 REINFORCING MATERIALS

- A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed. All reinforcing bars shall be Grade 60 unless otherwise noted. Provide Grade 75, Grade 80, or Grade 100 reinforcing bars where indicated on the contract documents.
- B. Weldable Reinforcing Bars: ASTM A 706/A 706M, Grade 60 (Grade 420).
- C. Mechanical Splice Couplers: ACI 318/ACI 318M, same material of reinforcing bar being spliced. Provide mechanical couplers as an alternate to standard tension lap splices where indicated on the contract documents and in areas of rebar congestion. A mechanical splice coupler shall develop in tension or compression, as required, at least 1.25 times the yield strength of the bar being spliced.
- D. Steel Wire and Welded Wire Reinforcement: ASTM A 1064. Galvanized at exterior locations, conditions permanently exposed to weather and/or water, and where noted on drawings (plan and/or sections).
- E. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.
- F. Supports for Reinforcement: Bolsters, chairs, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire reinforcement in place. Use wire bar type supports complying with CRSI specifications.
1. For exposed-to-view concrete surfaces, where legs of supports are in contact with forms, provide supports with legs which are plastic protected (CRSI, Class I) or stainless steel protected (CRSI, Class 2), at a spacing not to exceed 4'-0" on center in either direction.

2.3 CONCRETE MATERIALS

- A. Cement: Portland cement (ASTM C 150, Types I, II, or I/II) or Portland limestone cement (ASTM C 595). Total percentage of Portland Cement is NOT to exceed 75% of the cementitious content of each mix, except mixes assigned to exposure class F3. Use one brand of cement throughout project, unless otherwise acceptable to Architect. Provide supplementary cementitious materials in mixes per sections below.
- a. Fly Ash: Cast-in-place concrete shall incorporate fly ash as a replacement for at least 25% (by weight) of the Portland cement. All design mixes must be reviewed and approved by the Engineer of Record. Where concrete is assigned to exposure class F3, limit the replacement of Portland cement with fly ash (by weight) to 25% max.
 - b. Ground Granulated Blast Furnace Slag (GGBF): Cast-in-place concrete shall incorporate GGBF as a replacement for at least 40% (by weight) of the Portland cement. All design mixes

must be reviewed and approved by the Engineer of Record. Where concrete is assigned to exposure class F3, limit the replacement of Portland cement with GGBF slag (by weight) to 50% max.

- c. Post-Consumer Recycled Ground Glass Pozzolan (GGP): Cast-in-place concrete shall incorporate GGP as a replacement for at least 25% (by weight) of the Portland cement. All design mixes must be reviewed and approved by the Engineer of Record.
 - d. Pozzolans and Slags: These must be completely accounted for in the design mix. Mix design must meet minimum design requirements set in the contract documents. Additional admixtures may be required to meet early strength requirements and alternative cementitious material goals. If a "blended cement" is used which already contains a certain percentage of Pozzolans or Slags this content may offset or entirely satisfy the minimum percentage required.
 - 1) Coal Fly Ash: ASTM C 618 (Class C or Class F): ASTM C 618 (Note: Class F fly Ash will require higher amounts of air entraining admixtures than class C).
 - 2) Blast Furnace Slag: ASTM C989
 - 3) Ground Glass Pozzolan: ASTM C1866
 - 4) Silica Fume: ASTM C 1240
 - 5) Rice Hull (or "husk") Ash: ASTM C 618 Blended hydraulic cement, as defined by ASTM C 595 or ASTM C 1157
- B. Normal Weight Aggregates: ASTM C 33, and as herein specified. Provide aggregates from a single source for exposed concrete.
- 1. Local aggregates not complying with ASTM C 33 but which have shown by special test or actual service to produce concrete of adequate strength and durability may be used when acceptable to Architect.
 - 2. Normal weight Fine Aggregate: washed, inert, natural or manufactured or combination thereof, sand conforming ASTM C33 gradation.
 - 3. Normal weight Coarse Aggregate: well graded crushed stone or washed gravel conforming to ASTM C33, sizes 57 for foundations and 67 for slabs and structure.
 - a. Recycled crushed concrete aggregate in concrete mixes is only to be used with approval of Engineer of Record. Recycled aggregate shall be used only as a substitute for coarse aggregate and must also be washed and well-graded, conforming to ASTM C33.
 - b. For sub-base, slabs on grade and non-structural applications and Recycled Aggregate Materials are NOT required to meet the ASTM C 33 standard. In addition to concrete rubble, glass, porcelain, and tire chips can be used as filler material. Any inert material conforming to ASTM D1241 is acceptable for the applications described in this paragraph.
- C. Lightweight Aggregates: Well-graded crushed expanded shale produced by rotary kiln method. Solite or equal, conforming to ASTM C330.
- D. Water: Free from oils, acids, alkali, organic matter and other deleterious material to conform to ASTM C94. ASTM C94 for gray water use in the production of ready mixed concrete per approval by the Engineer of Record.
- E. Air Entraining Admixture: ASTM C 260.
- 1. Liquid air entrainment: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Air Mix"
 - b. "AEA-92"
 - c. "Darex AEA"

Euclid Chemical Co.

Euclid Chemical Co.

GCP Applied Technologies

d. "MasterAir AE200"

Master Builders Solutions

F. Water-Reducing Admixture: ASTM C 494.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

- | | |
|-------------------------|---------------------------|
| a. "MasterPolyheed 997" | Master Builders Solutions |
| b. "Eucon MR" | Euclid Chemical Co. |
| c. "WRDA 64" | GCP Applied Technologies |

G. High-Range Water-Reducing Admixture (Superplasticizer): ASTM C 494, Type F or Type G and containing not more than 0.05 percent chloride ions.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

- | | |
|-------------------------------------|---------------------------|
| a. "Eucon 37, 1037 or Plastol 5000" | Euclid Chemical Co. |
| b. "Rheobuild 1000" | Master Builders Solutions |
| c. "MasterGlenium Series" | Master Builders Solutions |
| d. "Daracem-100" | GCP Applied Technologies |

H. Water Reducing, Non-Corrosive Accelerating Admixture: The admixture shall conform to ASTM C 494, Type C or E, and not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year's duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures. Accelerating admixtures are not to be used as antifreeze agents. Accelerating admixtures are permitted only upon review by Engineer of Record.

1. Products: Subject to compliance with requirements, provide the following or equal approved by Engineer of Record:

- | | |
|------------------------------------|---------------------------|
| a. "Accelguard NCA, 80, 90, or G3" | Euclid Chemical Co. |
| b. "Daraset 400 or 422" | GCP Applied Technologies |
| c. "MasterSet FP 20" | Master Builders Solutions |

I. Water-Reducing, Retarding Admixture: ASTM C 494, Type D, and contain not more than 0.05 percent chloride ions.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

- | | |
|-------------------------------|---------------------------|
| a. "Eucon Retarder 75 or 100" | Euclid Chemical Co. |
| b. "MasterSet R 100" | Master Builders Solutions |
| c. "Plastiment" | Sika Chemical Co. |
| d. "Daratard" | GCP Applied Technologies. |

J. Microsilica Admixture shall be dry densified or slurry formed. Microsilica shall come from the same source throughout the project. If a single source cannot be maintained, laboratory testing of each new source shall be required before acceptance by the Engineer of Record at no cost to the owner.

1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

- | | |
|---------------------|--------------------------|
| a. "Emsac F 100" | Elkem Chemical, Inc. |
| b. "Eucon MSA" | Euclid Chemical Co. |
| c. "Force 10,000 D" | GCP Applied Technologies |

- K. Prohibited Admixtures: Calcium chloride, thiocyanates or admixtures containing more than 0.05 percent chloride ions are not permitted.
- L. Certification: Written conformance to the above-mentioned requirements and the chloride ion content of admixtures will be required from the admixture manufacturer prior to mix design review by the Engineer of Record.
- M. Corrosion Inhibitor: 30% calcium nitrite (where called for in the specifications or on the drawings). Subject to compliance with requirements, provide the following at 3 gal/cy:
 - 1. "Eucon CIA" Euclid Chemical Co.
 - 2. "DCI" GCP Applied Technologies
 - 3. "MasterLife CI 30" Master Builders Solutions
- N. Contractor will be required to provide information demonstrating successful use in prior placement involving all admixtures.

2.4 WATERSTOPS

- A. Flexible PVC Waterstops: CE CRD-C 572, for embedding in concrete to prevent passage of fluids through joints. Factory fabricate corners, intersections, and directional changes.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equal approved by Engineer of Record:
 - a. BoMetals, Inc.
 - b. Sika Greenstreak
 - c. Paul Murphy Plastics Company
 - d. Vinylex Corp.

2.5 GROUT

- A. Non-Shrink, Non-Metallic Grout: The non-shrink grout shall be a factory pre-mixed grout and shall conform to ASTM C1107, "Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-Shrink)." In addition, the grout manufacturer shall furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 4' x 4' base plate.
 - 1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "NS Grout" Euclid Chemical Co.
 - b. "Five Star Grout" Five Star
 - c. "SikaGrout-713" Sika Chemical Co.
- B. High Flow Grout: Where high fluidity and/or increased placing time is required, use high flow grout. The factory pre-mixed grout shall conform to ASTM C1107, "Standard Specification for Packages Dry, Hydraulic-Cement Grout (Non-shrink)." In addition, the grout manufacturer shall furnish test data from an independent laboratory indicating that the grout when placed at a fluid consistency shall achieve 95% bearing under a 18" x 36" base plate.
 - 1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Hi-Flow Grout" Euclid Chemical Co.
 - b. "SikaGrout-928" Sika Chemical Co.
 - c. "Five Star Fluid Grout 100" Five Star

2.6 RELATED MATERIALS

- A. Granular Fill: Clean mixture of crushed stone or crushed or uncrushed gravel; ASTM D 1241, Size 57, with 100 percent passing a 1-1/2 (37.5 mm) inch sieve and 0 to 5 percent passing a No. 8 (2.36 mm) sieve.
- B. Fine-Graded Granular Material: Clean mixture of crushed stone, crushed gravel, and manufactured or natural sand; ASTM D 1241, Size 10, with 100 percent passing a 3/8 inch (9.5 mm) sieve, 10 to 30 percent passing a No. 100 (0.15 mm) sieve, and at least 5 percent passing No. 200 (0.075 mm) sieve; complying with deleterious substance limits of ASTM C 33 for fine aggregates.
- C. Non-slip Aggregate Finish: Provide fused aluminum oxide grits, or crushed emery, as abrasive aggregate for non-slip finish with emery aggregate containing not less than 40% aluminum oxide and not less than 25% ferric oxide. Use material that is factory-graded, packaged, rustproof and non-glazing, and is unaffected by freezing, moisture, and cleaning materials.
- D. Absorptive Cover: Burlap cloth made from jute or kenaf, weighing approximately 9 oz. per sq. yd., complying with AASHTO M 182, Class 2.
- E. Moisture-Retaining Cover: One of the following, complying with ASTM C 171:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Waterproof paper
 - b. Polyethylene film
 - c. Polyethylene-coated burlap
- F. Curing Compounds: The compound shall conform to ASTM C 309. Limit VOC content to 130 g/L. Use water-based curing compound. For surfaces receiving both a curing compound and additional flooring, verify that the curing compound and additional flooring are compatible.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "SealTight 1100" W.R. Meadows
 - b. "Kurez W VOX" Euclid Chemical Co.
- G. Curing & Sealing Compounds: Only specify for slabs that will remain exposed, i.e. will not receive additional flooring. The compound shall conform to ASTM C1315. Limit VOC content to 130 g/L. Use water-based curing compound.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Super Diamond Clear VOX" Euclid Chemical Co.
 - b. "VOCOMP-25" W.R. Meadows
- H. Curing, Sealing, & Hardening Compounds: For use on concrete surfaces that will remain exposed. Slabs that will receive additional flooring do not require sealing or hardening. Sealers and hardeners must not yellow under ultra violet light after 500 hours of test in accordance with and have a maximum moisture loss of 0.039 grams per sq. cm. when applied at a coverage rate of 250 sq. ft. per gallon. Limit VOC content to 130 g/L. Use water- or vegetable-based product.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Kure-N-Harden" BASF

- I. For concrete floors subjected to heavy vehicular traffic use a Liquid Sealer/Densifier: The product must be a high performance, deeply penetrating concrete densifier conforming to ASTM C836; odorless, colorless, VOC - compliant, non-yellowing silicate based solution designed to harden, dustproof and protect and to resist black rubber tire marks on concrete surfaces. The compound must contain a minimum of 20% solids content of which 50% is silicate
- J. Evaporation Retardant:
1. Products Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Eucobar" Euclid Chemical Co.
 - b. "MasterKure ER 50" Master Builders Solutions
- K. Certify that all curing compounds, sealers and hardeners are compatible with all adhesive products intended for attaching co-lateral floor material. In conformance with ASTM F 710, coordination with flooring manufacturer is required to ensure concrete coatings will not obstruct the bond between the concrete and the adhesive. Ensure coatings and adhesives are "benignly compatible" - in other words, do not combine substances whose constituents are reactive. Reactivity releases VOCs and /or other toxic fumes.
- L. Crack Sealer: Elastomeric liquid crack sealer resistant to water, gasoline, oil and salts.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Eucoelastic 1NS" Euclid Chemical Co.
 - b. Maximum allowable depth of this product is 1/2".
- M. Underlayment Compound: Free flowing, self-leveling, pumpable cementitious base compound.
1. Products: Subject to compliance with requirements, provide the following or equal approved by Engineer of Record:
 - a. "EucoFloor SL 160" Euclid Chemical Co.
 - b. "Ardex" Ardex Co.
 - c. "MasterTop 110 SL" Sika Chemical Co.
- N. Bonding Admixture: The compound shall be a latex, non-rewettable type.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:
 - a. "Flex-Con" Euclid Chemical Co.
 - b. "SBR Latex" Euclid Chemical Co.
- O. High Strength Polymer Repair Mortar: For form and pouring or large horizontal repairs, provide the flowable on-part, high strength repair mortar.
1. Products: subject to compliance with requirements, provide the following or equal approved by Engineer of Record:
 - a. "Eucocrete or EucoRepair SCC" Euclid Chemical Co.
 - b. "Euco Speed MP" (Cold Weather) Euclid Chemical Co.
 - c. "Emaco R" Master Builders Solutions
- P. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- a. "Daraweld C" GCP Applied Technologies
 - b. "Acrylic Bonding Agent J40" Dayton Superior

c. Euroweld 2.0

Euclid Chemical Co.

- Q. Epoxy Bonding Adhesive: ASTM C 881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to suit requirements, and as follows:
1. Type IV for bonding hardened concrete to hardened concrete, and Type V for bonding freshly mixed concrete to hardened concrete.
- R. Reglets: Fabricate reglets of not less than 0.022 inch (0.55 mm) thick, galvanized-steel sheet. Temporarily fill or cover face opening of reglet to prevent intrusion of concrete or debris.
- S. Dovetail Anchor Slots: Hot-dip galvanized-steel sheet, not less than 0.034 inch (0.85 mm) thick, with bent tab anchors. Temporarily fill or cover face opening of slots to prevent intrusion of concrete or debris.
- T. Vapor Barrier: Provide vapor barrier which conforms to ASTM E 1745, Class A or B. The membrane shall have a water-vapor permeance rate no greater than 0.012 perms when tested in accordance with ASTM E 154, Section 7. The vapor barrier shall be placed over prepared base material where indicated below slabs on grade. Vapor barrier shall be no less than 10 mil thick in accordance with ACI 302.1R. Preferred vapor barriers will be manufactured from post-consumer recycled polymers.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. "Stego Wrap (15 mil) Vapor Barrier"	Stego Industries LLC
b. "Griffolyn Vaporguard"	Reef Industries
c. "Premoulded Membrane with Plastmatic Core"	W.R. Meadows.
- U. Expansion Joint Filler: ASTM D 1751.
1. Products: Subject to compliance with requirements, provide one of the following or equal approved by Engineer of Record:

a. "Homex 300"	Homasote Company
b. "Standard Cork Expansion Joint Filler"	APS Cork
c. "Fibre Expansion Joint"	W.R. Meadows
- V. Water: Potable.

2.7 PROPORTIONING AND DESIGN OF MIXES

- A. Preparation of Design Mixes
1. All mix designs shall be proportioned in accordance with Section 26.4.3.1(b) of ACI 318 and prepared by a licensed testing laboratory approved by the owner, but paid for by the contractor. Submit mix designs on each class of concrete for review.
 2. If previously used mixes are submitted, all materials shall be from the same sources and with the same brand names as the previously utilized mix.
 3. If trial batches are used, the mix design shall be prepared by an independent testing laboratory and shall achieve an average compressive strength 1200 psi higher than the specified strength. This over-design shall be increased to 1.10f_c+700 psi when concrete strengths greater than 5000 psi are used.
 4. The proposed mix designs shall be accompanied by complete standard deviation analysis or trial mixture test data.

- B. Submit each proposed mix to the Architect and Structural Engineer for review at least 5 days prior to the pre-concrete conference. Do not begin concrete production until Architect and Engineer of Record has reviewed and approved mixes.
1. Submit Test reports for any pozzolans or slags indicating compliance with ASTM C 618, ASTM C 989, or ASTM C1866 respectively.
 2. Provide cut sheets clearly indicating the percentages of pozzolans or slags used in the mix design as replacement for Portland cement. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the percentage.
 3. Test reports for recycled aggregate indicating compliance with ASTM C 33. Provide cut sheets clearly indicating the percentage of aggregates used that are recycled. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and source or sources of the material.
 4. Provide cut sheets clearly indicating the percentage of sub-base and filler aggregate materials that are recycled. Or, if cut sheets are not available, obtain a written affidavit from the manufacturer stating the recycled content percentage and source or sources of the material.
- C. Design mixes to provide concrete with strength as indicated on drawings and schedules.
- D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to Owner and as accepted by Architect and Engineer of Record. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect and Engineer of Record before using in work.
- E. Admixtures:
1. Use water-reducing admixture or high range water-reducing admixture (superplasticizer) in all concrete as required for placement and workability.
 2. Use non-corrosive, non-chloride accelerating admixture in concrete slabs placed at ambient temperatures below 50oF (10oC).
 3. Use high-range water-reducing admixture in pumped concrete, architectural concrete, parking structure slabs, fiber concrete, concrete required to be watertight, concrete with ultimate strength of 5,000 psi or more, and concrete with water/cement ratios below 0.50.
 - 4.
 5. Use air-entraining admixture in exterior exposed concrete, unless otherwise indicated. See the Concrete Mix Design table on the drawings for Exposure Class. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having total air content with a tolerance of plus-or-minus 1-1/2 percent within following limits:
 - a. Concrete structures and slabs exposed to freezing and thawing or deicer chemicals.
 - 1) 1-1/2" maximum aggregate: 4.5 percent (exposure class F1, moderate exposure); 5.5 percent (exposure class F2 and F3, severe exposure)
 - 2) 1" maximum aggregate: 4.5 percent (exposure class F1, moderate exposure); 6 percent (exposure class F2 and F3, severe exposure)
 - 3) 3/4" maximum aggregate: 5 percent (exposure class F1, moderate exposure); 6 percent (exposure class F2 and F3, severe exposure)
 - 4) 1/2" maximum aggregate: 5.5 percent (exposure class F1, moderate exposure); 7 percent (exposure class F2 and F3, severe exposure)
 - 5) 3/8" maximum aggregate: 6 percent (exposure class F1, moderate exposure); 7.5 percent (exposure class F2 and F3, severe exposure)

- b. Other Concrete: (not exposed to freezing, thawing, or hydraulic pressure): 2 percent to 4 percent air.
- c. Interior concrete to receive hard troweling shall not be air entrained unless specifically approved by the Engineer.
- 6. Use admixtures for water-reducing and set-control in strict compliance with manufacturer's directions.
- F. Water-Cement Ratio: Provide concrete for following conditions with maximum water-cement (W/C) ratios as follows:
 - 1. Concrete for architecturally exposed structural elements or architecturally exposed surfaces: W/C 0.40.
 - 2. Refer to the Concrete Mix Design table in the structural drawings for other W/C ratio requirements based on exposure class, element type, etc.
 - 3. Refer to the requirements for concrete by exposure class in ACI 318 for balance of info related to maximum W/C ratios, minimum f'_c values, and additional requirements.
- G. Slump Limits: Proportion and design mixes to result in concrete slump at point of placement as follows:
 - 1. Ramp slabs and sloping surfaces: Not more than 3".
 - 2. Reinforced foundation systems, including mud slabs below hydrostatic slabs: Not less than 1" and not more than 3".
 - 3. Concrete containing HRWR admixture (superplasticizer): Not more than 9" unless otherwise approved by the architect.
 - 4. Other Concrete: Not less than 1" or more than 4".
- H. Chloride Ion Level: Chloride ion content shall be tested by the laboratory making the trial mixes. The total chloride ion content of the mix including all constituents shall not exceed the limitations set forth in Table 19.3.2.1 of ACI 318.

2.8 CONCRETE MIXING

- A. Ready-Mix Concrete: Comply with requirements of ASTM C 94, and as herein specified.
- B. Provide batch ticket for each batch discharged and used in work, indicating project identification name and number, date, mix type, mix time, quantity, and amount of water introduced.
- C. During hot weather, or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C 94 may be required. When air temperature is between 85oF (30oC) and 90oF (32oC), reduce maximum mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 90oF (32oC), reduce maximum mixing and delivery time to 60 minutes.
- D. No water shall be added after mixing to concrete containing HRWR (Superplasticizer). If loss of slump occurs, the concrete treated with HRWR may be redosed as long as a "flash set" has not occurred. Redosage procedures must be discussed and approved by the Engineer of Record and the manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Coordinate the installation of joint materials and vapor retarders with placement of forms and reinforcing steel.

3.2 INSPECTION

- A. Examine all work prepared by others to receive work of this section and report any defects affecting installation to the Contractor for correction. Commencement of work will be construed as complete acceptance of preparatory work by others.

3.3 CONCRETE

- A. Concrete shall develop the minimum compressive strengths shown on drawings at 28 days when sampled and tested in accordance with ASTM C 31 and C 39 with the maximum slump in accordance with the approved mix design.
- B. Concrete shall be in accordance with the requirements and specifications of "Building Code Requirements for Structural Concrete" as modified by the building code noted above.
- C. Fly Ash Concrete & Slag Concrete: Concrete mixes containing high volumes of fly ash or Slag have slower set times and may take up to 56 days to reach full strength. The Engineer of Record, agency responsible for concrete mix design, the architect and the concrete subcontractor must coordinate to ensure that the form stripping schedule is consistent with the ability of the structure to support itself and all imposed construction loads.

3.4 FORMS

- A. Design formwork to maximize its reusability, reduce resources devoted to formwork construction and minimize waste generated. Where appropriate choose alternative formwork systems (refer to sections listed above).
- B. Design, erect, support, brace and maintain formwork to support vertical and lateral, static, and dynamic loads that might be applied until such loads can be supported by concrete structure. Construct formwork so concrete members and structures are of correct size, shapes, alignment, elevation and position. Maintain formwork construction tolerances complying with ACI 347. Provide Class A tolerances for concrete exposed to view. Provide Class C tolerances for other concrete surfaces.
- C. Design formwork to be readily removable without impact, shocks or damage to cast-in-place concrete surfaces and adjacent materials.
- D. Construct forms to size shapes, lines and dimensions shown, and to obtain accurate alignment, location, grades, level and plumb work in finished structures. Provide for openings, offsets, sinkages, keyways, recesses, moldings, rustications, reglets, chamfers, blocking, screeds, bulkheads, anchorages and inserts, and other features required in work. Use selected materials to obtain required finishes. Solidly butt joints and provide back- up at joints to prevent leakage of cement paste.

- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush plates or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces where slope is too steep to place concrete with bottom forms only. Kerf wood inserts for forming keyways, recesses, and the like, to prevent swelling and for easy removal.
- F. Provide temporary openings where interior area of formwork is inaccessible for cleanout, for inspection before concrete placement, and for placement of concrete. Securely brace temporary openings and set tightly to forms to prevent loss of concrete mortar. Locate temporary openings on forms at inconspicuous locations.
- G. Chamfer exposed corners and edges as indicated, using wood, metal, PVC or rubber chamfer strips fabricated to produce uniform smooth lines and tight edge joints.
- H. Provisions for Other Trades: Provide openings in concrete formwork to accommodate work of other trades. Determine size and location of openings, recesses and chases from trades providing such items. Accurately place and securely support items built into forms.
- I. Cleaning and Tightening: Thoroughly clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt or other debris just before concrete is placed. Retightening forms and bracing after concrete placement is required to eliminate mortar leaks and maintain proper alignment.

3.5 VAPOR BARRIER INSTALLATION

- A. Examine the condition of porous fill and remedy any unsatisfactory portions prior to installing vapor barriers.
- B. Sub-base material to be per above sections.
- C. Following leveling and tamping of sub-base for slabs on grade, place vapor barrier sheeting with longest dimension parallel with direction of pour.
- D. Lap joints 6" and seal with appropriate tape.
- E. After placement of moisture barrier, cover with granular material and compact to depth as shown on drawings.
- F. Avoid cutting or puncturing vapor barrier during reinforcement placement and concreting operations.

3.6 PLACING REINFORCEMENT

- A. Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars", for details and methods of reinforcement placement and supports, and as herein specified.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, and other materials, which reduce or destroy bond with concrete.

- C. Accurately position, support and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers, and hangers, as required.
- D. Place reinforcement to obtain at least minimum coverage's for concrete protection. Arrange, space and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
- E. Splices: Lap splices as indicated on Drawings.
 - 1. Bars indicated to be continuous, and all vertical bars shall be lapped not less than values indicated in the contract documents.
 - 2. Stagger splices in accordance with ACI 318/ACI 318M
 - 3. Mechanical Splice Couplers: Install in accordance with manufacturer's instructions.
 - 4. Weld reinforcing bars in accordance with AWS D1.4/D 1.4M, where indicated on Drawings.
- F. Install welded-wire reinforcement in longest practicable lengths.
 - 1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."
 - 2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches (50 mm) for plain wire and 8 inches (200 mm) for deformed wire.
 - 3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
 - 4. Lace overlaps with wire.

3.7 JOINTS

- A. Construction Joints:
 - 1. Construct joints true to line with faces perpendicular to surface plane of concrete.
 - 2. Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.
 - 3. Place joints perpendicular to main reinforcement. Continue reinforcement across construction joints, except as otherwise indicated.
 - 4. Locate joints for beams, slabs, joists, and girders in the middle third of spans.
 - a. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
 - 5. Locate horizontal joints in walls and columns at underside of floors, slabs, beams, and girders and at the top of footings or floor slabs.
 - 6. Locate joints beside piers integral with walls, near corners, and in concealed locations where possible.
- B. Waterstops: Provide waterstops in construction joints as indicated. Install waterstops to form continuous diaphragm in each joint. Make provisions to support and protect exposed waterstops during progress of work. Fabricate field joints in waterstops in accordance with manufacturer's printed instructions, using manufacturer's specified welding irons.
- C. Isolation Joints in Slabs-on-Ground: Construct isolation joints in slabs-on-ground at points of contact between slabs-on-ground and vertical surfaces, such as column pedestals and elsewhere as indicated.
- D. Joint filler and sealant materials are specified in the section for "Related Materials"

- E. Contraction (Control) Joints in Slabs-on-Ground: Maximum joint spacing shall be 36 times the slab thickness unless otherwise noted on the drawings. The dry cut saw shall be used immediately after final finishing and to a depth of 1-1/2". A conventional saw shall be used as soon as possible without dislodging aggregate and to a depth of 1/4 slab thickness.
 - 1. Joint sealant material is specified in the section for "Related Materials".

3.8 INSTALLATION TOLERANCES

- A. Comply with ACI 117/ACI 117M.

3.9 INSTALLATION OF EMBEDDED ITEMS

- A. General: Set and build into work anchorage devices and other embedded items required for other work that is attached to, or supported by, cast-in-place concrete. Use setting drawings, diagrams, instructions and directions provided by suppliers of items to be attached thereto.
- B. Edge Forms and Screed Strips for Slabs: Set edge forms or bulkheads and intermediate screed strips for slabs to obtain required elevations and contours in finished slab surface. Provide and secure units sufficiently strong to support types of screed strips by use of strike-off templates or accepted compacting type screeds.
- C. Embedded Plates at Foundation Walls: Install plate at top of forms so that exterior face of steel plate is level and plumb. Use construction documents for locations, sizes and elevations.

3.10 PREPARATION OF FORM SURFACES

- A. Clean re-used forms of concrete matrix residue, repair and patch as required to return forms to acceptable surface condition.
- B. If form-release compound is required, coat contact surfaces of forms with a form-coating compound before reinforcement is placed.
- C. Thin form-coating compounds only with thinning agent of type, and amount, and under conditions of form-coating compound manufacturer's directions. Do not allow excess form-coating material to accumulate in forms or to come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply in compliance with manufacturer's instructions.
- D. Coat steel forms with a non-staining, rust-preventative form oil or otherwise protect against rusting. Rust-stained steel formwork is not acceptable.

3.11 CONCRETE PLACEMENT

- A. Ready-mix concrete shall comply with the requirements of ASTM C 94 and ACI 304. All plant and transporting equipment shall comply with the concrete plant standards and truck mixer and agitator standards of the National Ready Mix Concrete Association.
- B. Cold weather mixing procedures shall be submitted to the architect for approval.

- C. Placement of structural concrete with a least dimension greater than or equal to 4 feet shall be considered "mass concrete" per ACI definition. Contractor shall adhere to mass concrete procedures and recommendations of ACI 301 and ACI 211.
- D. Notify Architect and Owner's Inspector at least 36 hours (1 1/2 regular working days) before each pour so that forms and reinforcing may be examined. Do not place concrete until inspection has been made or waived.
- E. Preplacement Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit installation of their work; cooperate with other trades in setting such work. Moisten wood forms immediately before placing concrete where form coatings are not used.
 - 1. Apply temporary protective covering to lower 2' of finished walls adjacent to poured floor slabs and similar conditions, and guard against spattering during placement.
- F. General: Comply with ACI 304 "Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete," and as herein specified.
 - 1. Deposit concrete continuously or in layers of such thickness that no concrete will be placed on concrete which has hardened sufficiently to cause the formation of seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as herein specified. Deposit concrete as nearly as practicable to its final location to avoid segregation.
- G. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers not deeper than 18" and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints. Use internal vibrators penetrating both the top and preceding layers.
- H. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding or tamping. Use equipment and procedures for consolidation of concrete in accordance with ACI recommended practices.
- I. Use and type of vibrators shall conform to ACI 309 "Recommended Practice for Consolidation of Concrete." Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations not farther than visible effectiveness of machine. Place vibrators to rapidly penetrate placed layer and at least 6" into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing segregation of mix.
- J. Placing Concrete Slabs:
 - 1. Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until the placing of a panel or section is completed.
 - 2. Per ACI 318, beams, girders, or slabs supported by columns or walls shall not be cast or erected until concrete in the vertical support members is no longer plastic.
- K. Consolidate concrete during placing operations so that concrete is thoroughly worked around reinforcement and other embedded items and into corners.
- L. Slabs: Bring slab surfaces to correct level with straightedge and strikeoff. Use highway straightedge, bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab

surfaces prior to beginning finishing operations. See also "MONOLITHIC SLAB FINISHES" below.

- M. Maintain reinforcing in proper position during concrete placement operations.
- N. Cold Weather Placing: Protect concrete work from physical damage or reduced strength which could be caused by frost, freezing actions, or low temperatures, in compliance with ACI 306 and as herein specified.
 - 1. When air temperature has fallen to or is expected to fall below 40oF (4oC), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50oF (10oC), and not more than 80oF (27oC) at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
 - 3. Use only a non-corrosive, non-chloride accelerator. Calcium chloride, thiocyanates or admixtures containing more than 0.05% chloride ions are NOT permitted.
 - 4. Care must be taken to store water-based curing and sealing compounds where they will not freeze. In most cases, they cannot be reconstituted after thawing.
- O. Hot Weather Placing: When hot weather conditions exist that would seriously impair quality and strength of concrete, place concrete in compliance with ACI 305 and as herein specified.
 - 1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90oF (32oC). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water. Use of liquid nitrogen to cool concrete is Contractor's option.
 - 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedment in concrete.
 - 3. Fog spray forms, reinforcing steel and subgrade just before concrete is placed.

3.12 FINISH OF FORMED SURFACES

- A. Concrete mixes containing pozzolans or slags do not set at the same rate or with the same bleed water characteristic as plain Portland cement. Therefore attention must be directed to the proper procedures. Refer to ACI 232.2R and ACI 301.
- B. Rough Form Finish: For formed concrete surface not exposed to view in the finish work or by other construction, unless otherwise indicated. This is the concrete surface having texture imparted by form facing material used, with tie holes and defective areas repaired and patched and fins and other projections exceeding 1/4" in height rubbed down or chipped off.
- C. Smooth Form Finish: For formed concrete surfaces exposed to view, or that are to be covered with a coating material applied directly to concrete, or a covering material applied directly to concrete, such as waterproofing, damp-proofing, painting or other similar system. This is as-cast concrete surface obtained with selected form facing material, arranged orderly and symmetrically with a minimum of seams. Repair and patch defective areas with fins or other projections completely removed and smoothed. Follow all requirements in ACI 301, Chapter 10 for smooth form finish. Surface preparation for surfaces receiving waterproofing must be approved by the waterproofing manufacturer prior to construction.

3.13 FLOOR FLATNESS/LEVELNESS TOLERANCES

- A. FF defines the maximum floor curvature allowed over 24 in. Computed on the basis of successive 12 in. (300 mm) elevation differentials, FF is commonly referred to as the "Flatness F-Number".
- B. FL defines the relative conformity of the floor surface to a horizontal plane as measured over a 10 ft. (3.05 m) distance commonly referred to as the "Levelness F-Number".
- C. All floors shall be measured within 72 hours of being poured and in accordance with ASTM E 1155 "Standard Test Method for Determining Floor Flatness and Levelness Using the "F Number" System (Inch-Pound Units).
- D. All slabs shall achieve the specified overall tolerance. The minimum local tolerance (1/2 bay or as designated by the architect) shall be 2/3 of the specified tolerances.
- E. All elevated slabs shall achieve the specified FL tolerance before the removal of the forms.

3.14 MONOLITHIC SLAB FINISHES

- A. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view, and slab surfaces to be covered with resilient flooring, carpet, ceramic or quarry tile, paint, or other thin film finish coating system, unless otherwise noted. After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance and with a surface leveled to an FF 35 / FL 20 tolerance (FL 20 for elevated slabs). Grind smooth surface defects, which would telegraph through applied floor covering system.
- B. Trowel and Fine Broom Finish: Where ceramic or quarry tile is to be installed with thin-set mortar, and slab surfaces which are to be covered with membrane or elastic waterproofing, or sand-bed terrazzo, and exterior walking surfaces, and as otherwise indicated, apply single trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming. Surface preparation for surfaces receiving waterproofing must be approved by the waterproofing manufacturer prior to construction.
- C. Sealers, Hardeners and Liquid Densifiers: Apply a coat of the specified compound to all EXPOSED interior concrete floors where indicated on the drawings. This surface must be continuously moist cured by a method satisfactory to the Architect. Apply and mechanically scrub compound into the floor in strict accordance with the manufacturer's printed instructions.

3.15 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
 - 1. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting, keep continuously moist for not less than 7 days.
 - 2. Begin final curing procedures immediately following initial curing and before concrete has dried. Continue final curing for at least 7 days in accordance with ACI 301 procedures. Avoid rapid drying at end of final curing period.

3. In order to avoid plastic or drying shrinkage cracks during warm, dry or windy weather, ACI 302 and ACI 308 shall be followed using wind breaks and sun shades when recommended.
 4. Care must be taken to store water based curing and sealing compounds where they will not freeze. In most cases, they cannot be reconstituted after thawing.
- B. Curing Methods: Perform curing of concrete by moisture curing, moisture-retaining cover curing, curing and sealing compound, and by combinations thereof, as herein specified.
1. Provide moisture curing by following methods.
 - a. Keep concrete surface continuously wet by covering with water.
 - b. Continuous water-fog spray.
 - c. Covering concrete surface with specified absorptive cover, thoroughly saturating cover with water and keeping continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with 4" lap over adjacent absorptive covers.
 2. Provide moisture-retaining cover curing as follows:
 - a. Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3" and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 3. Provide curing and sealing compound to exposed interior slabs not receiving additional flooring. A clear curing and sealing compound shall be used on exterior slabs, sidewalks and curbs not receiving a penetrating sealer.
 4. Use the specified curing compound on surfaces to be covered with finish or coating material applied directly to concrete, such as liquid densifier/sealer, waterproofing, dampproofing, membrane roofing, flooring, painting, and other coatings and finish materials. Apply compound in accordance with manufacturer's direction.
- C. Curing Formed Surfaces: Cure formed concrete surfaces, including undersides of beams, supported slabs and other similar surfaces by moist curing with forms in place for full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
- D. Curing Unformed Surfaces: Cure unformed surfaces, such as slabs, floor topping, and other flat surfaces by application of the specified curing compound or a continuous moist curing method approved by the architect.
- E. Certify that all curing compounds, sealers and hardeners are compatible with all adhesive products intended for attaching co-lateral floor material. In conformance with ASTM F710, coordination with flooring manufacturer is required to insure concrete coatings will not obstruct the bond between the concrete and the adhesive. In addition, insure coatings and adhesives are "benignly compatible" -- in other words, do not combine substances whose constituents are reactive.
- F. Sealer and Dustproofers: Apply a second coat of the specified curing and sealing compound to exposed interior slabs not subjected to vehicular traffic, noted on the drawings. These slabs must have received an initial coat of the curing and sealing compound.

3.16 SHORES AND SUPPORTS

- A. Contractor shall provide the services of a registered Professional Engineer to design the shoring, and determine timing of removal.

- B. Remove shores and reshore in a planned sequence to avoid damage to partially cured concrete. Locate and provide adequate reshoring to safely support work without excessive stress or deflection.
- C. Keep reshores in place a minimum of 15 days after placing upper tier, and longer if required, until concrete has attained its required 28-day strength and heavy loads due to construction operations have been removed.

3.17 REMOVAL OF FORMS

- A. Formwork not supporting weight of concrete, such as sides of beams, walls, columns, and similar parts of the work, may be removed after cumulatively curing at not less than 50oF (10oC) for 12 hours after placing concrete, provided concrete is sufficiently hard to not be damaged by form removal operations, and provided curing and protection operations are maintained.
- B. For formwork supporting weight of concrete, such as beam soffits, joints, slabs and other structural elements, comply with ACI 347 recommendations for various element types. Determine compressive strength of in-place concrete by testing field-cured specimens representative of concrete location or members.
- C. Form facing material may be removed 4 days after placement, only if shores and other vertical supports have been arranged to permit removal of form facing material without loosening or disturbing shores and supports.

3.18 RE-USE OF FORMS

- A. Clean and repair surfaces of forms to be re-used in work. Split, frayed, delaminated or otherwise damaged form facing material will not be acceptable for exposed surfaces. Apply new form coating compound as specified for new form work.
- B. When forms are intended for successive concrete placement, thoroughly clean surfaces, remove fins and laitance, and tighten forms to close joints. Align and secure joint to avoid offsets. Do not use "patched" forms for exposed concrete surfaces, except as acceptable to Architect.

3.19 MISCELLANEOUS CONCRETE ITEMS

- A. Filling-In: Fill-in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place and cure concrete as herein specified, to blend with in- place construction. Provide other miscellaneous concrete filling shown or required to complete work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and steel-troweling surfaces to a hard, dense finish with corners, intersections and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations, as shown on drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.

- D. Grout base plates and foundations as indicated using specified free-flowing non-shrink grout. Use non-metallic grout for exposed conditions, unless otherwise indicated.
- E. Where high fluidity and/or increased placing time is required use the specified high flow grout. This grout shall be used for all base plates larger than 10 square feet.
- F. Reinforced Masonry: Provide concrete grout for reinforced masonry lintels and bond beams where indicated on drawings and as scheduled. Maintain accurate location of reinforcing steel during concrete placement.

3.20 CONCRETE SURFACE REPAIRS

- A. Prior to all repairs, an as-built condition sketch and method of repair must be submitted to the Architect and Engineer of Record for review and approval.
- B. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removal of forms, when acceptable to Architect.
- C. Cut out honeycomb, rock pockets, voids over 1/4" in any dimension, and holes left by tie rods and bolts, down to solid concrete but, in no case to a depth of less than 1". Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with a bonding grout containing the specified bonding admixture. Place patching mortar after while bonding grout is still tacky.
- D. For exposed-to-view surfaces, blend white Portland cement and standard Portland cement so that, when dry, patching mortar will match color surrounding. Provide test areas at inconspicuous location to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.
- E. Repair of Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Architect. Surface defects, as such, include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets; fins and other projections on surface; and stains and other discoloration's that cannot be removed by cleaning. Flush out form tie holes, fill with dry pack mortar, or pre-cast cement cone plugs secured in place with bonding agent.
- F. Repair concealed formed surfaces, where possible, that contain defects that affect the durability of concrete. If defects cannot be repaired, remove and replace concrete.
- G. Repair of Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface plane to tolerances specified for each surface and finish. Correct low and high areas as herein specified. Test unformed surfaces sloped to drain for trueens of slope, in addition to smoothness, using a template having required slope.
- H. Repair finished unformed surfaces that contain defects, which affect durability of concrete. Surface defects, as such, include crazing, cracks in excess of 0.01" wide or which penetrate to reinforcement or completely through non-reinforced sections regardless of width, spalling, pop-outs, honeycomb, rock pockets, and other objectionable conditions.

- I. Correct high areas in unformed surfaces by grinding, after concrete has cured at least 14 days, except at hydrostatic slabs.
- J. Correct low areas in unformed surfaces during or immediately after completion of surface finishing operations by cutting out low areas and replacing with fresh concrete. Finish repaired areas to blend into adjacent concrete. The specified underlayment compound or repair topping may be used when acceptable to Architect.
- K. Repair defective areas, except random cracks and single holes not exceeding 1" diameter, by cutting out and replacing with fresh concrete. Remove defective areas to sound concrete with clean, square cuts and expose reinforcing steel with at least 3/4" clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding compound. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete.
- L. Repair isolated random cracks and single holes not over 1" in diameter by dry-pack method. Groove top of cracks and cutout holes to sound concrete and clean of dust, dirt and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Mix dry-pack, consisting of one part Portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing. Place dry-pack after bonding compound has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for not less than 72 hours.
- M. Structural Repair: All structural repairs shall be made with prior approval of the Engineer of Record as to method and procedure, using the specified polymer repair mortar and/or specified epoxy adhesive. Where epoxy injection procedures must be used, an approved low viscosity epoxy made by the manufacturers previously specified shall be used. In addition, all cracks shall be filled with the specified crack sealer or other method as approved by the Engineer of Record. All garage slabs shall be repaired prior to the slab being treated with the specified penetrating anti-spalling sealer.
- N. Underlayment Application: Leveling of floors for subsequent finishes may be achieved by use of specified underlayment material. Underlayment application shall achieve the tolerances specified in "MONOLITHIC SLAB FINISHES" above.
- O. Specified Polymer Horizontal Repair Mortar: All exposed floors shall be leveled, where required, with the specified self-leveling repair topping.
- P. Repair Methods not specified above may be used, subject to acceptance of Architect.

3.21 FOUNDATION WALLS

- A. The contractor shall form and leave openings in walls as shown on drawings and approved shop drawings for work of other contractors. These openings shall be temporarily closed and when so directed, the contractor shall point up in solid and neat manner with waterproofed cement.

3.22 WORK IN CONNECTION WITH OTHER TRADES AND CONTRACTS

- A. Sleeves, pockets, openings, etc., shall be set in the concrete walls and arches as required for the mechanical trades as shown on approved shop drawings; these shall be encased or built into the concrete work and shall be properly placed and secured in position in the forms before concrete is placed.
- B. Provide all chases, pipe slots, etc., required for the mechanical trades (see mechanical drawings), constructed as shown on the approved shop drawings.
- C. Leave temporary access panels where required to install mechanical equipment as required by trade affected. Panels shall be formed with construction joints as specified. Details for such panels shall be submitted to Architect for approval.
- D. Coordinate all penetrations, cutting, and patching with waterproofing contractor.

3.23 CUTTING AND PATCHING

- A. Contractor for concrete work shall be responsible for all cutting, removing and patching work where concrete surfaces are not installed within the limits shown on the drawings or specified herein. All such work shall meet with the approval of the Architect or Engineer of Record.
- B. Where cutting and patching is required to accommodate the work of other subcontractors, such cutting shall be done at the expense of said subcontractors but shall be performed by the contractor for concrete work.
- C. The location and extent of cutting in completed concrete work and the patching thereof shall meet with the approval of the Architect or Engineer of Record.

3.24 QUALITY CONTROL TESTING DURING CONSTRUCTION

- A. The Owner will employ a testing laboratory to perform tests and to submit test reports.
- B. Provide special inspections per the applicable Building Code and the requirements of all applicable ACI standards.
- C. Sampling and testing for quality control during placement of concrete may include the following, as directed by Architect.
 - 1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - 2. Slump: ASTM C 143; one test at point of discharge for each truck; additional tests when concrete consistency seems to have changed.
 - 3. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231 pressure method for normal weight concrete; one for each truck of air-entrained concrete.
 - 4. Concrete Temperature: Test hourly when air temperature is 40oF (4oC) and below, and when 80oF (27oC) and above; and each time a set of compression test specimens made.
 - 5. Compression Test Specimen: ASTM C 31; one set of 5 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.

6. Compressive Strength Tests: ASTM C 39; one set for each day's pour exceeding 25 cu. yds. plus additional sets for each 50 cu. yds. over and above the first 25 cu. yds. of each concrete class placed in any one day; one specimens tested at 7 days, three specimens tested at 28 days, and one specimens retained in reserve for later testing if required.
 - a. When frequency of testing will provide less than 5 strength tests for a given class of concrete, conduct testing from at least 5 randomly selected batches or from each batch if fewer than 5 are used.
 - b. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
 - c. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive strength by more than 500 psi.
7. Water Cementitious Ratio Test: Check water content of concrete in accordance with AASHTO T 318 "Standard Method of Test for Water Content of Freshly Mixed Concrete Using Microwave Oven Drying". Frequency of this test shall be the same as that of compressive strength tests, noted above.
8. Floor Preparation to Receive Resilient Flooring: For any concrete that receives resilient flooring, test concrete in accordance with ASTM F 710 prior to acceptance by owner.
9. Test results will be reported in writing to Architect, Engineer of Record, and Contractor within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day tests.
 - a. Non Compliance: All test reports indicating non-compliance shall be faxed immediately to all parties on the test report distribution list and the hard copies submitted on different colored paper.
 - b. Nondestructive Testing: Windsor probes, sonoscope, or other non-destructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
10. Additional Tests: The testing service will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by Architect. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. Contractor shall pay for such tests when unacceptable concrete is verified.

3.25 WASTE MANAGEMENT

- A. Separate and recycle waste materials in accordance with the Section 017419 Construction Waste Management and Disposal and to the maximum extent feasible.
- B. Collect cut off steel and discarded reinforcement steel and place in area for recycling.
- C. Place materials defined as hazardous or toxic waste in designated containers.
- D. Use trigger operated spray nozzles for water hoses and closed loop system to reduce water consumption.

- E. Reusable forms should be cleaned immediately after removal and non-reusable forms recycled to the maximum extent economically feasible.
- F. Incorporate crushed concrete or masonry materials in sub-base to the maximum extent feasible in accordance with sub-base specifications.
- G. Before concrete pours, designate location or uses for excess concrete. Options include:
 - 1. Additional paving
 - 2. Post footing anchorage
 - 3. Landscaping -- site concrete features
 - 4. Flowable fill
- H. To avoid contamination of the local landscape, before concrete pours, designate a location for cleaning out concrete trucks where run-off can be contained, reused or incorporated. Options include:
 - 1. Company owned site for that purpose
 - 2. On-site area to be paved later in project

END OF SECTION

SECTION 03 3500 - CONCRETE COLOR & FINISHING**PART ONE- GENERAL****1.1 SUMMARY****A. Section Includes:**

Provide finishes on cast-in-place concrete as called for on the Drawings, specified herein, and needed for a complete and proper installation

B. Related Sections:

03 30 00 Cast-in-Place Concrete

05 50 00 Metal Fabrications

07 92 00 Joint Sealants

1.2 SUBMITTALS**A. General:**

1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
2. Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit all items listed below.

B. Product Data:

Within 30 calendar days after the Contractor has received the Owner's Notice to Proceed, submit:

1. A complete list of materials proposed to be furnished and installed under this Section.
2. Manufacturer's specifications and other data needed to demonstrate compliance with specified requirements.
3. Manufacturer's recommended installation procedures which, when approved by the Owner, will become the basis for accepting or rejecting actual installation procedures used on the work.

C. Sample Panels:

For each type of concrete paving including finish, color, aggregates and hardeners as specified:

1. Provide 2-foot by 2-foot mock-up under 01 45 00 Quality Control. Construct at least one month before start of other concrete work to allow concrete to cure before observation.
2. At location acceptable to owner, demonstrate methods used for construction, including forming and finishing conditions required for Project using materials, workmanship, joint treatments, and curing methods to be used throughout Project.
3. Modify per Owner's directions at no cost to the Owner.
4. Accepted mock-up provides visual standard for work of Section.

1.3 QUALITY ASSURANCE**A. Standards:**

Comply with pertinent provisions of following standards, in case of conflict between referenced standards, the more stringent requirements shall govern.

1. ACI 301, latest edition, "Specifications for Structural Concrete for Buildings".
2. International Building Code, latest edition, as amended by local authority.
3. American Society for Testing and Materials (ASTM), latest edition.
4. American Association of State Highway and Transportation Officials, Specifications for Materials (AASHTO), latest edition.
5. Americans with Disabilities Act (ADA)

B. Standard Specifications:

Conform to all applicable requirements of the local building code, latest edition.

C. Qualifications of Workers:

1. Provide at least one person trained in the skills required, who shall be: completely familiar with the design and application of work described for this section, present at all times during progress of the work, and shall direct all work performed under this section.
2. For finishing of portland cement concrete surfaces, and operation of the required equipment, use only personnel trained in the skills required.

1.4 DELIVERY, STORAGE AND HANDLING**A. General:****B. Comply with the pertinent provisions of Sections of 01 60 00 Product Requirements.****C. Protection:**

1. Use all means necessary to protect the materials of this section before, during, and after installation and to protect the work and materials of all other trades.
2. Protect cement concrete paving against vehicular traffic prior to and for 28 days following installation.

D. Color Additive: Deliver, store and handle in accordance with manufacturer's instructions.**PART TWO - PRODUCTS****GENERAL:****A. Carefully study the Drawings and these Specifications, and determine the location, extent, and type of required concrete finishes.****B. As required for the Work, provide the following materials, or equals approved by the owner.****2.1 CONCRETE MATERIALS****A. Comply with pertinent provisions of Section 03 3000, except as may be modified herein.****2.2 LIQUID BONDING AGENT:****A. "Sonobond" epoxy concrete bonding agent as manufactured by Sonneborn Building Products.****2.3 LIQUID CURING AGENTS:****A. Type conforming to ASTM C309, fully compatible with proposed finish coatings or coverings, or the application of such finish.****B. Where application of specified finish materials will be inhibited by use of curing agents, cure the surface by water only, do not use chemical cure.****C. "Sonosil" curing agent as manufactured by Sonneborn Building Products.****2.4 SEALER/HARDENER:****A. "Sonosil" curing, hardening, dust-proofer as manufactured by Sonneborn Building Products.****2.5 CURING AND PROTECTION PAPER:****A. Non-staining reinforced waterproof kraft paper conforming to ASTM C171.****B. Where concrete will be exposed and will be subjected to abrasion, such as floor slabs, use non-staining paper such as "Sisalkraft", "Seekure 896" or equal paper faced with polyethylene film.****2.6 BURLAP CLOTH:****A. Made from jute or kenaf and weighing approximately 305 grams per sq. m (9 oz. per sq. yd.) for moist curing. Conform to AASHTO M 182, use two layers.**

2.7 INTEGRAL CONCRETE COLORANTS

A. General:

1. All Finish Layers will be integrally colored.
2. Conform to ASTM C979.
3. UV stable:
Provide mineral pigments, which are UV stable, and completely colorfast for a minimum of 10-years following installation.
4. Concrete Mix Compatibility
Assure compatibility of selected pigments with proposed concrete mix design and admixtures.

B. Color:

Submit manufacturer's standard and custom concrete colors to Consultant for final color selections.

C. Manufacturer's Recommendations:

Conform to all manufacturer's recommendations for mixing, finishing, and curing colored concrete.

1. Approved Manufacturers:
2. Davis Colors, www.daviscolors.com.
3. Scofield 'Chromix' Color Admixtures, www.scofield.com.
4. 'BrickForm' Rafco Products: www.brickform.com.

2.8 GROUT

A. Non-Metallic, Non-Shrink Cement Grout:

"10K Grout" as manufactured by BASF Construction Chemicals, (800) 433-9517.

2.9 OTHER MATERIALS

A. General:

Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Owner.

PART THREE - EXECUTION

3.1 SURFACE CONDITIONS

A. Existing Conditions:

Correct conditions detrimental to proper and timely completion of the work.

B. Unsatisfactory Conditions:

Do not proceed until unsatisfactory conditions have been corrected.

3.2 02 FINISHING OF FORMED SURFACES

A. General:

1. After removal of forms, give the concrete surfaces one or more of the finishes specified below where so indicated on the Drawings.
2. Revise the finishes as needed to secure the approval of the Owner.

B. As Cast Finish:

1. Rough Form Finish:
 - a) Provide as-cast rough form finish to all formed concrete surfaces that are to be concealed in the finish Work or by any other construction.

- b) Leave surfaces with the texture imparted by forms, except patch tie holes and defects with grout.
- c) Remove fins exceeding 1/4-inch in height.
- 2. Architectural finish:
 - a) Provide as-cast smooth form finish for all formed concrete surfaces in Animal Care areas or that are to be covered with a coating material other than cement plaster applied directly to the concrete.
 - b) Produce smooth form finish by selecting form material to impart a smooth, hard, uniform texture and arranging forms in an orderly and symmetrical manner with a minimum of seams in accordance with the requirements of section 03 10 00 Concrete Formwork.
 - c) Repair and patch defective areas with grout. remove and smooth all fins and other projections completely.
- 3. Related unformed surfaces:

At tops of walls, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces, strike off smooth and finish to match adjacent surface.

3.3 FINISHING SLABS

A. Definitions of Finishing Tolerances:

- 1. "Class A":

True plane within 1/8 inch (3.18 mm) in ten (10) feet as determined by a ten foot straight edge placed anywhere on the slab in any direction.
- 2. "Class B":

True plane within 1/4 inch (6.35 mm) in ten (10) feet as determined by a ten foot straight edge placed anywhere on the slab in any direction.
- 3. "Class C":

True plane within 1/8 inch (3.18 mm) in two (2) feet as determined by a two foot straight edge placed anywhere on the slab in any direction.

B. Screeds:

- 1. Set edge forms and intermediate screed strips accurately to produce the designed elevations and contours in the finished surface.
- 2. Screeds and forms will be sufficiently strong to support vibrating bridge screeds or roller pipe screeds if the nature of the finish specified requires the use of such equipment.
- 3. Align the concrete surface to the contours of screed strips by the use of strike-off templates or approved compacting type screeds.

C. Float finish:

- 1. General;

Apply float finish to monolithic slab surfaces that are to receive trowel finish and other finishes as specified, and to slab surfaces which are to be covered with insulation, and as otherwise shown on the Drawings or in the schedule.
- 2. After placing concrete slabs, do not work the surface further until ready for floating.
- 3. Begin floating when the surface water has disappeared and when the concrete has stiffened sufficiently to permit operation of a power-driven float, or both.
- 4. Consolidate the surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units.
- 5. Check and level the surface plane with a ten-foot straightedge placed on the surface at not less than two different angles.
- 6. Cut down high spots and fill low spots to produce a surface with a Class B surface throughout.

7. Uniformly slope to drains where required.
 8. Immediately after leveling, refloat the surfaces to a smooth, uniform, granular texture.
- D. Trowel Finish:
1. General:
Apply troweled finish to monolithic slab surfaces that are to be exposed to view, unless otherwise shown, and to slab surfaces that are to be covered with resilient flooring, carpeting, paint, or other thin-film finish coating system.
 2. Provide Float finish as described above,
 3. Begin the first trowel finish operation using a power-driven trowel. Begin final troweling when the surface produces a ringing sound as the trowel is moved over the surface.
 4. Consolidate the concrete surface by the final hand troweling operation, free from trowel marks, uniform in texture and appearance, and with Class A surface finish throughout.
 5. For surfaces which are intended to receive floor coverings grind smooth those surface defects which would telegraph through applied floor covering system.
 6. Final leveling may require interior floor underlayment leveling material to achieve required finish.
- E. Non-slip Broom Finish:
1. Apply nonslip broom finish to exterior concrete platforms, interior and exterior steps, interior and exterior ramps, interior and exterior animal holding areas, and elsewhere as shown on the Drawings or in the schedules.
 2. Provide a floated finish as described above.
 3. Light Broom Finish:
Surface grooves or grains less than 1/16-inch deep.
 4. Medium Broom Finish:
Surface grooves or grains greater than 1/16-inch and less than 1/8-inch deep.
 5. Heavy Broom Finish:
Surface grooves or grains greater than 1/8-inch and less than 1/4-inch deep.
 6. Immediately after trowel finishing, uniformly texture the concrete surface by drawing a fiberbristle broom across the surface.
 7. Texture in the direction perpendicular to the main traffic route unless shown otherwise on the Drawings.
 8. Coordinate the required finish with Owner prior to application.

3.4 PROTECTION AND CURING

- A. General:
Protect freshly deposited concrete from premature drying and excessively hot or cold temperatures, and maintain without drying at relatively constant temperature for the period of time necessary for the hydration of the cement and proper hardening of the concrete.
- B. Preservation of Moisture:
Apply one of the following materials or methods to concrete not in contact with forms, immediately following placement:
1. Ponding or continuous sprinkling.
 2. Absorptive mat or fabric kept continuously wet.
 3. Sand or other covering kept continuously wet.
 4. Application of waterproof sheet material specified in part 2 of this Section.
 5. Application of curing agent specified in part 2 of this Section.
- C. Temperature, Wind, and Humidity:
1. Cold Weather:

- a) When the mean daily temperature outdoors is less than 40 degrees Fahrenheit (4.44 degrees Celsius), maintain the temperature of the concrete between 50 degrees Fahrenheit (10 degrees Celsius) and 70 degrees Fahrenheit (21.11 degrees Celsius) for the required curing period.
 - b) When necessary, provide proper and adequate heating system capable of maintaining the required heat without injury due to concentration of heat.
 - c) Do not use combustion heaters during the first 24 hours unless precautions are taken to prevent exposure of the concrete to exhaust gases which contain carbon dioxide.
2. Hot Weather:
When necessary, provide wind breaks, fog spraying, shading, sprinkling, ponding, or wet covering with a light colored material, applying as quickly as concrete hardening and finishing operations will allow.
 3. Rate of Temperature Change:
Keep the temperature of the air immediately adjacent to the concrete during and immediately following the curing period as uniform as possible and not exceeding a change of 5 degrees Fahrenheit (-15 degrees Celsius) in any one hour period, or 50 degrees Fahrenheit (10 degrees Celsius) in any 24 hour period.
- D. Duration of Curing:
1. Continue curing until the cumulative number of days or fractions thereof, not necessarily consecutive, during which temperature of the air in contact with the concrete is below 50 degrees Fahrenheit (10 degrees Celsius) has totaled seven days.
 2. If high early strength of concrete has been used, continue curing for a total of three days.
 3. Prevent rapid drying at the end of the curing period.
- E. Formed Surfaces:
- Forms in contact with the concrete during the final curing period shall be kept wet. If forms are to be removed during the curing period, employ immediately one of the above curing materials or methods. Continue for the remainder of the curing period.
- F. Protection from Mechanical Injury:
- During the curing period, protect the concrete from damaging mechanical disturbances, particularly load stresses, heavy shock, and excessive vibration. All finished concrete surfaces to be protected from damage caused by construction equipment, materials, or methods, and by rain or running water. Self-supporting structures shall not be loaded in such a way as to overstress the concrete.

3.5 SEALER HARDENER

A. Application:

Apply Sealer/Hardener to all exposed concrete surfaces except where other finishes are noted.

Apply sealer/hardener after complete curing and drying of the concrete surface and per manufacturer's recommendations for the specific application. DO NOT APPLY OVER SURFACES TO RECEIVE INCOMPATIBLE FINISHES.

1. Dilute the liquid hardener with water and apply three coats:
 - a) First Coat: 1/3 strength;
 - b) Second Coat: 1/2 strength;
 - c) Third Coat: 2/3 strength.
2. Apply all coats evenly and allow 24 hours drying time between coats.

PART FOUR - SCHEDULE OF FINISHES

4.1 SPECIFIC FINISHES

- A. General: Provide the finishes defined above in the following locations.
- B. Concrete Walls
 - 1. Concrete Retaining Walls Integral Color, Architectural Finish, Class B
 - 2. Concrete Stem Walls Integral Color, Architectural Finish, Class B
 - 3. Concrete Dig Barriers Integral Color, Architectural Finish; Stain Exposed Surface, Class C

END OF SECTION

FOR REFERENCE ONLY

SECTION 03 3713 - SHOTCRETE**PART 1 GENERAL****1.1 SECTION INCLUDES**

- A. Simulated natural rock, trees/logs, and earth forms, and paving using pneumatically projected concrete (shotcrete).
- B. Structure and finishes for planter walls, paving, trees, pools and waterproofing.
- C. Work in two steps:
 - 1. A reinforced shotcrete structural substrate.
 - 2. An integrally colored and textured finish coat.
- D. Work of this section includes:
 - 1. Free standing artificial rock and earth
 - 2. Planter walls finished as artificial rock and earth
 - 3. Pools and waterproofing finished as artificial rock and earth
 - 4. Barrier finished as artificial trees/logs
 - 5. Artificial Rockwork - Arabian Rock
- E. Related work described elsewhere
31 00 00 Earthwork

1.2 REFERENCE STANDARDS

- A. ACI SPEC-506.2 - Specification for Shotcrete; 2013 (Reapproved 2018).
- B. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- C. ASTM A1064/A1064M - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete; 2024.
- D. ASTM C1602/C1602M - Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete; 2022.
- E. ASTM C33/C33M - Standard Specification for Concrete Aggregates; 2024a.
- F. ASTM C150/C150M - Standard Specification for Portland Cement; 2024.
- G. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete; 2024.
- H. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete; 2024.
- I. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum
- J. NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate components of the work of this section with work performed by other section in sufficient time to allow for other components of the work to incorporate requirements of this section without causing delay to the work, including the following:
 - 1. Foundations of adjacent structures.
 - 2. Remaining existing structures.
 - 3. Drains and piping for the pool.
- B. Pre-construction meeting: Arrange a site meeting attended by the Contractor's superintendent, the subcontractor's representative and foreman for this project, the consultant, materials supplier(s), and other relevant personal in accordance with section 01 General conditions before commencement of work for this section ; agenda for meeting will include the following:

1. Confirmation of specifications and details for the project.
2. Review of required fastening and joining methods.
3. Review of samples.
4. Review of finishing methods and proposed coatings.
5. Additional items that are required for identification of installation and fabrication concerns.

1.4 DEFINITIONS

- A. General: The words "Guniting" and "Shotcrete" may be used interchangeably in the Drawings or in the Specifications.
1. Wet Mix Process shall consist of premixed fine aggregate, cement, and water pneumatically applied by suitable mechanism.
 2. Dry Mix process shall consist of a mixture of fine aggregate and cement, pneumatically placed by a suitable mechanism and to which water is added immediately prior to discharge from the applicator.

1.5 SYSTEM DESCRIPTION:

- A. Delegated Design:
1. The work of this section requires professional design services or certifications by design professionals employed by the fabricator, and who are not the Consultant.
- B. Artistic Systems:
1. Provide artistic development and artistic interpretation of the concepts expressed on the drawings by completing the required models and submittals.
 2. Perform the fabrication of artificial rockwork and the placement and installation of finish details and exhibit accessories in such a manner as to replicate the natural geology and vegetation described by the written descriptions and reference photographs contained herein and shown on the drawings.
 3. Finishes:
 - a) Finishes are described in Part 4 of this section.
 - b) Finish locations are shown on the drawings.
- C. Standard of Quality:
1. Exhibit Design Drawings: The design, layout, and details referenced by this Section have been developed for the purposes of establishing a standard of quality for the work. At its option the Contractor may propose alternative means and methods of construction: including alternative materials, waterproofing systems, and structural systems.
 2. Alternative Means and Methods: Alternative means and methods will be considered only when fully described at the time of tendering, on the form provided on tender documents and when substantiated by the Contractor's submittal of the following information:
 - a) Manufacturer's specifications for proposed materials.
 - b) Minimum of three (3) projects where the proposed materials or structural systems have been used successfully.
 - c) Complete structural analysis and certification by a structural engineer registered in all pertinent jurisdictions with control over this project.
 3. Final selection of specific materials for each exhibit element must be approved by the Consultant.
 4. Provide appropriate documentation that all proposed materials meet the specific performance requirements specified below.
- D. Specific Performance Standards:

1. All materials and/or completed fabrications must have a twenty (20) year structural service life.
2. Materials must be capable of resisting any visible damage and wear for a 5-year active service life.
3. Exhibit materials located within the reach of visitors must be capable of resisting damage from normal touch or the forces that one might normally expect from the public for a period of no less than 10-years.
4. All integral and applied color must resist fading for a minimum of 5 years of active service life in the locations specified.
5. All exposed surfaces and finishes shall use non-toxic materials.
6. All materials shall be cleanable and UV resistant.
7. Grout voids solid or provide 31-inch (800mm) diameter access panels in locations concealed from any views of guests.

E. Structural Systems Design:

1. Structural Design:
 - a) Provide the structural engineering design of walls, structures, pools, and paving. Design the concrete mixes, concrete reinforcing, required concrete thicknesses, attachments, and support armatures.
 - b) Design drawings will be prepared, approved, signed and sealed by a Professional Engineer registered in the jurisdiction in which the project will be constructed.
2. Design Requirements:
 - a) Comply with this Specification Section, its referenced documents and all applicable Codes and Standards.
 - b) Design all elements for the following loads defined in the applicable building codes:
 - 1) Dead loads
 - 2) Loads due to snow and rain
 - 3) Wind loads
 - 4) Vehicle impact
 - 5) Earth retaining loads
 - 6) In addition to the above loads, design all elements for the following loads:
Concentrated gravity live load of 12 kips at any one location.
 - c) Design all elements using load combinations given in the building code applicable to the project.
 - d) Design the concrete mixes, concrete reinforcing, required concrete thicknesses, attachments, and support armatures.
 - e) Design foundations for all work of this Section as described in Foundation Design below.
3. Structural Design Coordination:
 - a) Design the openings and rebates required for the work of Section 08 80 00.
 - b) Design the inlet and outlet structures and the penetrations for pipe systems as required for the work of Section 22 55 00.
4. Geotechnical Investigations and Recommendations:
 - a) The following geotechnical investigations and recommendations provide the basis for the structural and foundation design of the work of this section:
 - b) Geotechnical Investigation, See 02 31 00 Soil Investigations
5. Foundation Design:
 - a) Design the foundations in accordance with all pertinent recommendations of the Geotechnical Investigations, and the following clarifications and additions.

- b) Design the foundations to limit movement due to frost heave or soil movement.
- 6. Subgrade and Backfill Design:
 - a) Design sub-grades and structural fills in accordance with all pertinent recommendations of the Geotechnical Investigations.
 - b) Provide all subgrades and structural fills required by the work of this section.
 - c) Provide all sub-drainage required by the work of this section.
- F. Electrical Bonding and Equipotential Plane:
 - 1. Equipotential Plane:
 - a) Provide an equipotential plane for all water holding basins and those concrete surfaces within 5-feet of those basins.
 - 2. Bond the equipotential plane in accordance with the US National Electrical Code Article 547 and 680.
 - 3. Bonding: Provide bonding for the equipotential plane and for all metal structures, surfaces, and fixed metal equipment per all requirements of the US National Electrical Code Article 547 and 680.
- G. Building Permits: The Contractor will obtain all required permits and approvals for proposed and alternative structural systems.

1.6 SUBMITTALS

- A. General:
 - 1. Comply with all requirements of Section 01 General Requirements.
 - 2. Thirty days prior to starting work, submit description of proposed equipment, and methods for the Owner's approval, including the following:
 - a) Sources for all materials.
 - b) Proposed equipment for use on this project.
 - c) Qualifications of the artificial rockwork company, foreman, nozzleman, artists, and crew as specified under quality assurance below.
 - d) Structural design drawings and calculations as required herein.
- B. Design Drawings:
 - 1. Delegated Design:
 - a) Submit complete drawings accurately indicating all proposed structures and equipment described in this Section, prepared in accordance with the following provisions:
 - b) Verify materials selection and sizes.
 - c) Verify fabrication and connection details for the structures or suggest alternative connection details.
 - d) Design system utilizing the system components specified in Part 2 of this Section.
 - e) Revise drawings as required by the permitting authorities and resubmit.
 - 2. Delegated Design Submittals:
 - a) Provide all submittals described in Section 01 33 50 – Delegated Design Submittals as required for the work of this Section.
 - 3. Design Notes and Calculations: Submit design notes and calculations; signed and sealed by Professional Engineer when requested by Consultant.
- C. Test Reports and Certificates: Thirty days prior to starting work submit for approval:
 - 1. Proposed mix design and test results that document the capability of the mix design to meet the specified requirements of this section.
 - 2. Mill certificates: Furnish certified copies of cement, silica-fume, and pozzolan mill test reports showing compliance with drawings and specifications.

3. Aggregate test reports: Furnish tests documenting that aggregate used in the work meets requirements specified herein.
 4. Admixture test report: Submit copies of tests showing conformance with requirements of ASTM C494.
- D. Shop Drawings: Forty-five days prior to starting work submit for approval:
1. Lift drawings describing the geometry of the structure, location of construction joints, expansion joints, pipe penetrations, anchor bolts, embedded electrical conduits, and other embedded items.
 2. Shop drawings that clearly show the location and size of all footings, thickness and reinforcing of all shotcrete structures.
 3. Drawings must be to scale and at an appropriate size for adequate review and signed and sealed by a professional engineer.
 4. Submit details for glazing rebates based upon dimensions provided by the glazing installer
- E. Product data: Thirty days prior to starting work submit for approval:
1. Furnish specifications and installation instructions for water stops, sealants, grouts, epoxies and curing compounds, anchor bolts, inserts and other embedded items.
 2. Color chart for integral color selection.
- F. Samples:
1. Prior to beginning work submit one sample panel (dimensions described in Part 4) for each specific texture coat finish as specified in Part 4 of this section, to the Owner for approval.
 2. Sample panels may not be used as part of the final work.
 3. Sample panels shall represent the finished surfaces, texturing, coloring, etching, etc. and specified structural capabilities & durability. Panels will be used as the basis for approval and acceptance of the work.
 4. Panels shall not be removed until the completion of all work.
 5. Rejected sample panels shall be re-submitted for approval at no additional cost to the Owner.
- G. Models: Within sixty days after the Contractor has received the Notice to Proceed, submit the following for approval of the Owner:
1. Provide a 1/2"= 1'-0" scale model(s) of the work shown on the drawings.
 2. The model(s) shall clearly show the shape, sizes, conformation and relationships between all elements.
 3. The model(s) shall clearly show the relationship between the Work of this Section and all related Work of other Contractors.
 4. Following the Owner's review provide one (1) set of modifications to the model.
 5. Following its approval, the model(s) will establish the three dimensional character which will govern all work of this Section.
 6. Model must be maintained on site - within view of the work - during construction as a working tool, available to artists and Owner. Protect from weather and construction damage. No modifications to the model can be made during construction without written approval of the Owner.

1.7 QUALITY ASSURANCE

- A. Codes:
1. International Building Code, Chapter 19 edition indicated on the Drawings and local amendments.
 2. Conform to all applicable requirements of the local building codes, latest editions.

3. All applicable requirements of the local building code, latest edition.
- B. Standards: Comply with pertinent provisions of following standards:
1. American Society for Testing and Materials (ASTM), latest edition.
 2. ACI (American Concrete Institute) 506R-05, Guide to Shotcrete (US)
 3. ACI 506.1R-08 Guide to Fiber Reinforced Shotcrete (US/CAN)
 4. ACI 506.2-95 Specification for Shotcrete (US/CAN)
 5. ACI 318 Building Code Requirements for Reinforced Concrete.
 6. ACI 305R Hot Weather Concreting (US)
 7. ACI 306R Cold Weather Concreting (US)
 8. CRSI "Manual of Standard Practice" (US)
 9. ACI 315, latest edition, "Manual of Standard Practice for Detailing Reinforcing Bars" (US)
- C. Consultant's Direction:
1. It is intended that the finished products of work in this section simulate natural formations of rock and earth.
 2. To achieve these simulations the Shotcrete Contractor will coordinate and cooperate fully with all other Contractors and with the Consultant.
 3. The Consultant explicitly reserves the right to monitor the work for aesthetic quality and to assume control of the work through direction of the Shotcrete contractor's project superintendent until specified effects are achieved.
- D. Qualifications of the Shotcrete Contractor:
- The Shotcrete Contractor must meet the following qualifications:
1. Established firm with a minimum of five (5) years experience in successfully constructing artificial earth and rock formations for natural habitat exhibits of similar nature to this project.
 2. Foreman:
Project Foreman with a minimum of 3000-hours experience in the management of similar project crews and experience in coordination with other trades in the completion of simulated artificial rockwork fabrication projects.
 3. Nozzleman:
Certified as required by ACI 506.3R with a minimum of 3000-hours and able to demonstrate by test their abilities to apply shotcrete as required by the specifications.
 4. Artists:
Provide artists skilled, to the Consultant's satisfaction, in the simulation of natural formations of rock, earth, and vegetation to supervise and perform the application of all aesthetic work.
 5. Project Personnel:
Provide full documentation of all construction crew members listing specific personnel to be used and detailing the experience of each person listed and their ability to perform all phases of the work to the Consultant's satisfaction.

1.8 TESTING

A. Responsibility for Testing

Routine testing services will be performed by a Testing Laboratory designated by the Owner. These testing services will be performed at the expense of the Owner.

B. Testing Services

The designated Testing Laboratory will:

1. Test the proposed materials, for compliance with specifications.
 2. Review proposed mix proportions and mix test results.
 3. Test preconstruction test specimens
- C. Secure production samples of materials at plants or stockpiles during construction and test for compliance with specifications. If the materials fail to meet approved requirements, aggregate will be rejected and the expense of testing shall be borne by Contractor.
1. Test strength of the Shotcrete as work progresses.
- D. Rejection of concrete:
1. The Owner may reject any batch of concrete which does not comply with the approved mix design, or which fails to comply with the Contract Documents when tested in accordance with the relevant codes.
 2. The Owner may reject any batch of concrete where a delivery docket containing all relevant information is not available, or is unsatisfactory, and may reject any concrete after placement because of unsatisfactory finish, incorrect position, or other failure to comply with the Contract Documents.

1.9 SURVEYING

- A. General
1. The Contractor will provide surveying for layout as frequently as is required to accurately locate all work of this section.
 2. Confirm locations, elevations, and profiles of work in progress or completed work by surveying regularly.
 3. Provide survey notes from a registered surveyor for each layout by the surveyor to the Consultant.
- B. Tolerance:
- Tolerance for location of any point on paving, pool bottoms or on walls defined on the drawing is 1-inch in both horizontal and vertical dimensions except where elements of the work require greater precision.

1.10 PRODUCT HANDLING

- A. General:
- Comply with the pertinent provisions of Sections of 01 General Requirements.
- B. Cement
1. Store cement in weather tight enclosures to protect against dampness and contamination.
 2. Discard cement that shows signs of deterioration unless testing demonstrates that it conforms with the requirements stated herein.
- C. Aggregates
- Prevent segregation and contamination of aggregates by proper arrangement and use of stockpiles.
- D. Admixtures
- E. Store admixtures properly to prevent contamination, evaporation, freezing, or other damage.

PART 2 PRODUCTS

2.1 SHOTCRETE FABRICATORS

- A. Acceptable Fabricators:
1. The following list of fabricators and installers is derived from previous projects indicating a successful record of fabrication and installation of similar complexity and extent as

required for this project and are subject to verification of their capabilities before starting work of this section by submittal of documentation indicating that they meet the specified qualifications:

- a) Cost of Wisconsin
Contact: Jeff Sheiber
Telephone: 407-816-2110 ext. 2101
Email: jsheiber@cost-inc.com
www.cost-inc.com
 - b) Edge Concrete, Woodinville, Washington
Contact: Wendy Endres
Telephone: 425-482-3343
Email: wendy@edgeconcretellc.com
www.edgeconcretellc.com
 - c) The Nassal Company, Orlando, Florida
Telephone: 407-648-0400
www.nassal.com
2. Substitute Fabricators:
- a) The Contractor may choose to select any of the listed fabricators or installers in accordance with Section 01 General conditions or elect to solicit additional fabricators/installers having similar qualifications, experience and proven capabilities as the acceptable installers listed above and provided that the contractor makes requests for substitution in accordance with Section 01 25 00 - Substitutions, a minimum of 10 (ten) days in advance of Bid closing as follows:
 - 1) Bidders wishing to use a fabricator or installer that is not identified in this section must have the proposed fabricator comply with qualification requirements listed herein and submit a letter of qualification, including references a minimum of five (5) 8 1/2" x 11" color photographs of previous comparable work for review and acceptance by the consultant.
 - 2) Fabricators wishing to be accepted for the work of this section may independently make application directly to the consultant as detailed above.
 - 3) Acceptance of substitute fabricators will be indicated by a subsequent addendum.
 - 4) The Consultant may require additional information and may request a visit to a completed work in order to make a final determination of the fabricator's qualifications.
 - 5) Acceptance of substitute fabricators will be indicated by a subsequent addendum.
 - 6) The Consultant may require additional information and may request a visit to a completed work in order to make a final determination of the fabricator's qualifications.

2.2 MATERIALS

- A. Cement: ASTM C150/C150M, Type I - Normal; white color.
- B. Aggregate: Normal weight, ASTM C33/C33M, 3/8 inch (9 mm) maximum size.
 1. Recycled Content:
Porcelain, concrete, stone, or other recycled content material conforming to requirements of mix design. Minimum 5% to 10% post-consumer recycled content, or minimum 30% pre-consumer recycled content at contractor's option.

2.3 ADMIXTURES: CHEMICAL TYPE COMPLYING WITH ASTM C494/C494M (WET MIX ONLY).**A. General:**

1. When the use of admixtures or cement containing additives is approved or specified, use strictly in accordance with the manufacturer's instructions and at approved dosage levels.
2. Admixtures shall not adversely affect the reinforcement or any protective coating thereon.

B. Silica-fume (micro silica):

1. Dry, densified dry, or slurry.
2. Comply with ASTM C1240

C. Superplasticizers

1. Meet requirements of ASTM C 484, Type F or G
2. Superplasticizers:
 - a) A synthesized sulfonated complex polymer type superplasticizer containing no chlorides or other corrosive chemicals, or alkalines.
 - b) Add to concrete mix at manufacturer's recommended dosage to allow placement with concrete temperatures up to 90 degrees F.
 - c) Provide performance on project by trial mixes or reduce temperature to below 80 degrees F by other means.
3. Manufacturer and product
 - a) Master Builders, Inc. Cleaveland, OH, Rheobuild
 - b) W. R. Grace & Co., Cambridge, MA, Daracem 100
 - c) Euclid Chemical Co., Cleaveland, OH, Eucon Super F or 537 G

D. Water Reducing Admixture:

1. ASTM C494, Type A or D, may be used at Contractor's option, subject to approval of mix design. AS 1478.

E. Fly Ash and pozzolanic admixtures:

1. Conforming to ASTM C 618 for Class F pozzolan. Report the chemical analysis of the fly ash in accordance with ASTM C311. Evaluate and classify fly ash in accordance with ASTM D5759.
2. The following limitations to ASTM C618 shall apply:
 - a) Loss of ignition maximum 3.0%
 - b) Fineness (percent retained #325 mesh) maximum 20%
 - c) Calcium oxide content maximum 10%
 - d) Sulfur trioxide content maximum 0.75%
3. Mercury Content:
 - a) Limited to less than 5.5 ppb (0.0055mg/L)
 - b) Comply with LEED for Healthcare's limits

F. Colorants

1. Pigments for coloring cement and concrete shall comply with ASTM C979 and ASTM C494 for water reducing admixtures.

G. Air-Entraining Admixture: Complying with ASTM C260/C260M (wet mix only).

1. Air entraining agent will result in an entrained air content of 4% +/- 1%

H. Corrosion Inhibitor

1. Calcium nitrite 30% plus or minus 2% by weight in aqueous solution.
2. Conform to ASTM C494, Type C.

3. Manufacturer and product:
 - a) W.R. Grace and Co., DCI or DCI-S
 - b) Master Builders, Rheocrete CNI
- I. Calcium Chloride:
 1. Conforming to ASTM D 98, in predissolved flake or pellet form. Use only upon written authorization of the Consultant.
- J. Waterproofing Admixture: Admixture formulated to reduce permeability to liquid water, with no adverse effect on concrete properties.
 1. Admixture Composition: Crystalline, functioning by growth of crystals in capillary pores.
 2. Potable Water Contact Approval: National Science Foundation (NSF) certification for use on structures holding potable water, based on testing in accordance with NSF 61 and NSF 372
 3. Manufacturers:
 - a) Aquafin IC ADMIX crystalline Admixture or Approved alternate. Install per manufacturer's instructions.. between the structural substrate and the textured finish coat.

2.4 REINFORCING BARS AND DOWELS:

ASTM A 615, Grade 60, unless otherwise noted.

- A. Reinforcing Mesh: ASTM A1064/A1064M steel welded wire reinforcement, plain type; W1.4 (w1.4), galvanized.
- B. Tie Wire: Annealed iron 1.25 diameter minimum
- C. Supports for reinforcement: Provide supports for reinforcement including bolsters, chairs, spacers and other devices for spacing supporting, and fastening reinforcement bars.

2.5 SYNTHETIC FIBER-REINFORCED CONCRETE

- A. Confirm that fibers will not be detrimental to the animals or the LSS system where shotcrete is in contact with water
- B. Fibers:
 1. 100 percent virgin polypropylene, multifilament fibers containing no reprocessed olefin materials and specifically manufactured for use as concrete secondary reinforcement.
 2. Comply with ASTM C-1116-91 Type 111
 3. Fiber manufacturer must document evidence of 5-year satisfactory performance history.

2.6 WATER:

- A. ASTM C1602; clean, potable, and not detrimental to shotcrete.
- B. Water free from oil, acid, organic matter or other substances deleterious to the concrete or its reinforcement.

2.7 WATERSTOPS

- A. PVC Bulb Type:
 1. 3/8-inch thick heavy-duty, ribbed center bulb type. Waterstops for expansion joints: 9 inches wide; all other waterstops: 6 inches wide.
 2. Polyvinyl chloride (PVC) plastic, meeting the following minimum requirements:
 - a) Tensile Strength 1,800 psi
 - b) Elongation 300%
 - c) Shore A Durometer 50
 3. Test in accordance with ASTM D 412. No reclaimed PVC will be allowed.
 4. Manufacturer: Greenstreak or equal: www.greenstreak.com

B. Active Waterstops:

1. General: Sodium bentonite and butyl rubber based water stops designed to stop water infiltration through cast-in-place concrete
2. Products and Manufacturers:
 - a) Volclay Waterstop - RX, 3 available shapes, manufactured by CETCO Building Material Group
 - b) Adcor 500s, manufactured by WR Grace

2.8 CEMENTITIOUS WATERPROOFING

A. Genral

1. Provide waterproofing on all surfaces, which are intended to contain water.
2. Provide waterproofing membranes in the following locations:
 - a) Pools and streams
3. Cementitious coating - Aquafin 2KM
 - a) Coating System: Aquafin 2KM flexible cementitious membrane or approved alternate.
 - b) Provide complete system including all of the manufacturer's recommended companion products whether or not specifically included herein.
 - c) Install in accordance with all of the manufacturer's recommendations.

2.9 SHOTCRETE MIX DESIGN

- A. Provide wet or dry mix design that gives good compaction and low percentage of rebound, is stiff enough not to sag.
- B. Design Objectives: The primary objectives to be satisfied by the Contractor in the selection, combination, and use of concrete materials are:
 1. Achievement of specified concrete strengths.
 2. Achievement of specified or implied durability requirements.
 3. Achievement of appropriate workability and consistency to permit placement as required by the work of this section.
 4. Strict compliance with the specified shrinkage l
 - a) Selection of appropriate sound aggregates having proven low shrinkage characteristics
 - b) Strict control of quality and cleanliness of all aggregates during production, supply and use, to minimize the content of deleterious fine materials.
 - c) Appropriate combination of materials to achieve minimum water demand.
- C. Design mix:
 1. Prepare the design mix for each type and strength of shotcrete by either laboraory trial batch or field experience methods as specified in ACI 301 an
 2. Submit recommended mix proportions in accordance with this section.
 3. Select proportions on the basis of compressive strength tests of specimens continuously moist cured until testing at 28 days.
- D. Design strength ad admixtures: (shotcrete holding water).
 1. Water holding structures: 24 inches above waterline - **Option A**
 - a) Compressive strength at 28 days 6,000psi (40 Mpa). 675lb/cyd total cement content with maximum water/cement ration of 0.40.
 - b) Maximum slump = 2 inches
 - c) Maximum aggregate size = 1/2 inch
 - d) Silica-fume: 68lb/cyd.

- e) Aquafin-IC ADMIX: manufacturer's recommended optimum mix percentage for maximum waterproofing.
- f) Synthetic fiber-reinforcement: 1.5lb/cyd (walls only).
- g) Superplasticiser as required.
- h) Corrosion inhibitor: 3 gallons per cubic yard.
- 2. Water holding structures: 24 inches above waterline - **Option B**
 - a) Compressive strength at 28 days 6,000psi
 - b) Maximum slump = 2 inches
 - c) Maximum aggregate size = 1/2 inch
 - d) Silica-fume: replace 5% to 10% of Portland cement. Mix in accordance with ASTM C94.
 - e) Fly ash; Replace 20% to 25%
 - f) Aquafin-IC ADMIX: manufacturer's recommended optimum mix percentage for maximum waterproofing.
 - g) Synthetic fiber-reinforcement: 1.5lb/cyd (walls only)
 - h) Water reducers and retarders to suit mix design
 - i) Superplasticiser as required.
 - j) Corrosion inhibitor: 3 gallons per cubic yard.
- 3. Structures not holding water:
 - a) Compression strength at 28 days 4,000psi (30Mpa), 675lb/cyd total cement content with maximum water/cement ration of 0.40.
 - b) Maximum slump = 2 inches
 - c) Maximum aggregate size = 1/2 inch
 - d) Silica-fume: 68lb/cyd
 - e) Synthetic fiber-reinforcement: 1.5lb/cyd
 - f) Water reducers and retarders to suit mix design
 - g) Superplasticiser as required.
- 4. Field trial mix:
 - a) After completion of mix design work and prior to concreting operations, establish, based upon the design mixes, field proportions for concrete to be used in the work. Manufacture the field trial concrete utilizing the equipment which will be used on the job.
 - b) The field trial concrete batch shall be 2 cubic yards mainimum per test. Adjust design mixes as required to provide a dense, homogeneous, durable concete with good workability and finishing qualities.
 - c) Obtain six standard test cylinders from each field trial mix and test as in mix design. Notify consultant in advance of any field trial mix work. No field trial mix shall be made without representatives of the consultant and the accepted testing laboratory being present.

2.10 MOISTURE RETAINING COVER

- A. Coverings:
 - 1. Apply absorptive mat or burlap fabric, sand, or other covering kept continuously wet for
 - 2. Layer of waterproof paper or plastic membrane as approved.
- B. Membrane forming curing compound:
 - 1. Cure the concrete by the application of an approved liquid curing membrane.
 - 2. Application shall be by means of a low-pressure spray at the rate recommended by the manufacturer.

3. On horizontal surfaces, apply the membrane immediately after finishing the concrete, and on vertical surfaces immediately after removing the formwork.
4. Insure that curing compounds do not interfere with the applicaiton of the texture coat to the structural substrate, or the application of finish colors and textures to the texture coat.

2.11 INTEGRAL CONCRETE COLORANTS

- A. General:
 1. All finish layers will be integrally colored.
 2. Conform to ASTM C979.
 3. UV stable Provide mineral pigments, which are UV stable and completely colorfast for a minimum of 10 years following installation.
 4. Concrete Mix compatibility: Assure compatibility of selected pigments with proposed concrete mix design and admixtures.
- B. Color: Submit manufacturer's standard and custom concrete colors to consultant for final color selections.
- C. Manufacturer's recommendations: Conform to all manufacturer's recommendations for mixing, finishing, and curing colored concrete.
- D. Approved manufacturer's:
 1. Davis Colors, www.daviscolors.com
 2. Sika 'Chromix' Color admixtures, www.usa.sika.com
 3. 'BrickForm' Rafco products, www.brickform.com

2.12 ACID REACTIVE STAINS

- A. Acid reactive stains:
 1. Reactive acid-based stain composed of inorganic metallic salts dissolved in an acid and water solution.
 2. The acid based stain reacts with the concrete forming a permanent chemical bond with the concrete,
 3. Colors
 - a) Provide a range of earth colors capable of achieving the effects specified in this secxtion and on the drawings.
 - b) Colors guaranteed for a minimum of 10 years with no more than 25% fade.
 4. Verify that proposed stains are appropriate for the condiditons that will affect the exhibit: local microclimate, and other bleaching or corrosive environments.

2.13 PAINTS

- A. General
 1. Provide painted finish to all appurtenances that penetrate or are otherwise integrated aesthetically with the shotcrete specified in this section.
 2. These include but are not limited to plastic and metal skimmers, exposed wall and pool penetrations, light fixtures, electrical boxes and cover.
- B. Materials
 1. Provide paint coatings appropriate for the material to be coated.
 2. Plastic and resin materials: For coating plastic materials use Krylon fusion. www.krylon.com

2.14 NATURAL STONE

- A. General:
 1. Provide a range of sizes of pieces of naturally weathered stone where necessary to achieve the finishes described in Part 4 of this section.

2. Match the color and textures of the natural stone to the finishes specified for artificial rockwork in Part 4 of this section.
 3. Material to be free from extraneous materials.
- B. Sources:
1. Comply with all requirements of Section 32 14 60 Select Boulders and cobbles.
 2. Provide samples to consultant for approval.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that conditions are acceptable and are ready to receive work.
- C. Verify that field measurements are as indicated on drawings.
- D. Verify fabricated forms are:
 1. True to line and dimension.
 2. Adequately braced against vibration during placement.
 3. Constructed to permit escape of trapped air during gunning operations.
 4. Constructed to minimize rebound during gunning operations.
- E. Verify correct placement of reinforcement with sufficient clearances to permit complete encasement.
- F. Verify that embedded fittings, pipe, conduits, and other items are correctly and securely placed.
- G. Ensure easy access to shotcrete surfaces for screeding and finishing, and to permit uninterrupted application.

3.2 GENERAL

- A. Structural substrate: Provide a structural substrate, capable of maintaining the intended shape, containing water in pools, and supporting live and dead loads as specified herein or as required by codes.
- B. Texture Coat
 1. Produce the intended color and texture.
 2. Provide mix design appropriate for integral color, carving, and texturing, and other aesthetic treatment to create the specified finishes.
 3. Provide sufficient thickness to assure structural integrity and bonding to the structural substrate.
 4. Provide sufficient thickness to create the specified recreations of natural forms and finishes.
- C. Latex Molds:
 1. Make latex molds of natural rocks as approved in submittals.
 2. Use latex molds or latex skins to create fine texture surfaces either for cast rock panels or to create finish for texture coat at required areas.
 3. Provide sufficient thickness to create the specified recreations of natural forms and finishes.
- D. Placement of Cast Rock Panels:
 1. Where cast rock panels are specified or have been approved, place into proper position by shimming and bracing as necessary, then shoot seams between panels solid with texture coat.
 2. Carve seams to mimic surface of cast panels and vertical or horizontal line of formation.

3.3 PREPARATION

- A. Remove existing unsound concrete from substrate surfaces.
 - 1. Minimize abrupt changes in depth of area to be repaired.
 - 2. Remove square external corners from substrate by radiusing the edges.
- B. Sandblast surfaces to receive shotcrete.
- C. Clean and wet cementitious or absorptive substrate surfaces prior to receiving shotcrete. Keep porous surfaces damp for several hours prior to placement of shotcrete.
- D. Protect adjacent surfaces not receiving shotcrete.

3.4 APPLICATION

- A. Place reinforcement in accordance with ACI 506.2.
- B. Use mixing and delivery equipment capable of thoroughly mixing aggregate, cement, and water in sufficient quantity to maintain continuous and uniform placement.
- C. Build-up to required thickness in multiple passes to achieve layering. Encase reinforcement with the first pass.
- D. Remove rebound at construction and expansion joints.
- E. Remove rebound material that does not fall clear of work; discard salvaged rebound.

3.5 FORMING SHOTCRETE STRUCTURES

- A. Formwork costs:
 - 1. Include all forming costs in the contract price
 - 2. No extra will be paid for shotcrete forming that is required by the grading and layout plans as drawn.
- B. Formwork:
 - 1. Provide forms or any rigid material such as wood, steel, earth, paperbacked reinforcing mesh, or expanded metal lath.
 - 2. Adequately brace and secure formwork to prevent vibration or deflection during the application of shotcrete.
 - 3. Design formwork to provide for the escape of compressed air and rebound during shotcreting.
- C. Form coatings:
 - 1. Use form-coating material on removable forms to prevent absorption of moisture and to prevent bond with the shotcrete.
 - 2. Use a non-staining material for surfaces exposed to view when construction is completed.
 - 3. The form-coating material shall not interfere with subsequent bonding to the shotcrete when this is required.

3.6 PROVISIONS FOR OTHER TRADES

- A. General:
 - 1. Provide openings in shotcrete formwork to accommodate work of other trades. Determine size and location of openings, vents, weepholes, recesses, and chases from trades providing such items.
 - 2. All non-sleeved piping shall be set by the appropriate contractor.
 - 3. Sleeves shall be provided by the appropriate contractor and installed by the shotcrete contractor.
 - 4. Accurately place and securely support items built into forms.
- B. Interpretive components:

1. Provide openings, recesses, and provisions for attachment in shotcrete formwork and finish coats for installation of graphic panels, sculptures, embedded artwork, and interpretive props, as shown on the drawings or as referenced in the work of other contracts.

3.7 REINFORCING

A. General

1. Install reinforcing which complies with all requirements of ASI 506R-90 and these drawings and specifications.
2. Clean reinforcement of loose rust, mill scale, earth, ice, and other materials, which reduce or destroy bond with concrete.
3. Accurately position, support and secure reinforcement against displacement by concrete placement operations. Locate and support reinforcing by metal chairs, runners, bolsters, spacers and hangers, as required.
4. Notify consultant upon completion of reinforcing and prior to placing shotcrete.

B. Fibrous Concrete Reinforcement

1. Add fibrous concrete reinforcement to concrete materials at the time concrete is batched in amounts specified in accordance with approved submittals for each type of concrete required.
2. Mix concrete in strict accordance with fiber reinforcement manufacturer's instructions and recommendations for uniform and complete distribution.

3.8 BATCHING AND MIXING CONCRETE

A. Batching and Mixing Equipment:

1. Use batching and mixing equipment capable of proportioning and mixing all ingredients at a rate that will provide adequate production, and with an accuracy that will insure uniformity of batches.
2. Weighing equipment shall be capable of batching with the accuracy specified in ASTM C94.
3. Volumetric equipment shall be capable of batching with the accuracy specified in ASTM C685.

- #### B. Dry State Delivery: Ready-mixed concrete shall comply with ASTM C94, except that it may be delivered to the shotcrete equipment in the dry state if that equipment is capable of adding the water and mixing it satisfactorily with the dry ingredients, or with ASTM C685, in which case the ingredients are delivered dry and proportioned and mixed at the site.

3.9 PLACING SHOTCRETE

- #### A. General: Place shotcrete using suitable delivery equipment and procedures that will result in shotcrete in place meeting the requirements of this specification.

B. Placement Techniques:

1. Control thickness, method of support, air pressure, and/or water content of shotcrete to preclude sagging or sloughing off.
2. Discontinue shotcreting or provide suitable means to screen the nozzle stream if wind or air currents cause separation of the nozzle stream during placement.
3. Broom or scarify the surface of freshly placed shotcrete to which, after hardening, additional layers of shotcrete are to be bonded. Dampen surface just prior to application of succeeding layers.
4. First, fill the sound material all corners and any area where rebound cannot escape or be blown free. Complete the corners between the web and the flanges of structural steel before application to the flat areas.

5. Provide a supply of clean, dry air adequate for maintaining sufficient nozzle velocity for all parts of the work and, if required, for simultaneous operation of a suitable blow pipe for clearing away rebound.
- C. Placement Around Reinforcement:
 1. Hold the nozzle at such distance and angle to place material behind reinforcement before any material is allowed to accumulate on its face. In the dry mix process additional water may be added to the mix when encasing reinforcement to facilitate a smooth flow of material behind the bars.
- D. Do not place shotcrete through more than one layer of reinforcing steel rods or mesh in one application unless demonstrated by preconstruction tests that steel is properly encased. Test to ascertain if any voids or sand pockets have developed around or behind reinforcement by probing with an awl or other pointed tool after the shotcrete has achieved its initial set; by removal of randomly selected bars; or by coring or other suitable means.
- E. Cover of Reinforcement:
 1. Provide the following minimum cover over reinforcement:
 - a) For linings or coatings: 3/4 inch (18mm) for fine aggregate and 1 1/2 inch (36mm) for coarse aggregate.
 - b) For principal reinforcement in beams, girders, and columns: 2 inch (50mm).
 - c) For reinforcement in slabs and walls 3/4 inch (18mm) for fine aggregate and 1 1/2 inch (36mm) for coarse aggregate.
 - d) For reinforcement near surfaces that retain water: 2 1/2 inches.
 2. Minus tolerance on cover shall be 3/8 inch (10mm) except that it shall not be greater than one-third of the specified cover.
- F. Line and Thickness Control: Use adequate ground wires or other accepted means to establish the thickness, surface planes, and finish lines of the shotcrete. Maintain specified tolerances by keeping ground wires secure and taut.
- G. Placement Precautions:
 1. Do not place shotcrete if drying or stiffening of the mix takes place at any time prior to delivery to the nozzle.
 2. Do not use rebound or previously expended material in the shotcrete mix.
 3. Remove all overspray or rebound prior to final set and before placement of shotcrete material on such area.

3.10 JOINTS

- A. Construction Joints:
 1. Install construction joints in accordance with the contract documents and approved shop drawings.
 2. Taper construction joints to a shallow edge form, about 25mm (1-inch) thick, except where the joint will be subjected to compressive stress. In this case, use non tapered joints and take special care to avoid or remove trapped rebound at the joint.
 3. Thoroughly clean and wet entire joint prior to the application of additional shotcrete.
 4. Make joints perpendicular to the main reinforcement. Continue reinforcement across joints.
- B. Control Joints:
 1. Install control joints in accordance with the contract documents and approved shop drawings.
 2. Do not extend reinforcement or other embedded metal items, which are bonded to the shotcrete, continuously through control joints.

- C. Aesthetic Placement of Joints: Position construction and control joints to conform to the locations of cracks and joints in the simulated rock and earth forms as shown in drawings.

3.11 PREPARATION OF SURFACES FOR WATERPROOFING & FINISH COAT

- A. Repair of Surface Defects:
1. Remove and replace shotcrete which lacks uniformity, exhibits segregation, honeycombing, or lamination, or which contains any dry patches, slugs, voids, or sand pockets.
 2. Repair defective areas by a method acceptable to the Consultant.
 3. Repair core holes in accordance with Chapter 9 of ACI 301. Do not fill core holes with shotcrete.
 4. Replace any shotcrete, which subsides after placement.
- B. Cleaning:
1. Clean surfaces and remove all form coating compounds, laitance, dirt and other foreign matter.
 2. Remove by brooming, vacuum, or other methods as required by the manufacturer's suggested surface preparation.
- C. Preparation for Waterproofing:
1. Provide all surface preparation and repairs recommended by the waterproofing system manufacturer.
 2. Employ all recommended secondary products to prepare the substrate properly.

3.12 WATERPROOFING

- A. General:
1. Provide waterproofing on all structures, which will hold water, and as otherwise indicated on the drawings.
 2. Waterproofing to have (2) components:
 - a) Structural Substrate with Aquafin-IC ADMIX (described above) or approved substitute.
 - b) Cementitious Waterproofing applied between the structural and texture coat as shown in the drawings.
 3. Place waterproofing on the surface of the structural coat in a manner suitable for the placement of the texture coat.
- B. Installation of Waterproofing:
1. Install waterproofing in accordance with all of the manufacturer's recommendations.
 2. Provide additional precautions or provisions where project conditions require them for a successful installation.
 3. Insure that all surfaces have cured for the period recommended by the manufacturer.
 4. Prior to commencing installation obtain the owner's review of the substrate.
- C. Protection of Other Work:
1. Do not allow debris, liquid or mastic compounds to enter and clog drains and other openings.
 2. Prevent spillage and migration onto other surfaces of work, by masking or otherwise protecting adjoining work.
 3. Where work interfaces with that of other trades, coordinate activities.
- D. Hydrostatic Testing:
1. Following installation of the waterproofing and prior to the installation of the texture coat, fill all water containing shotcrete structures with water to operational level.

2. Mark the test water level and maintain without the addition of water for a period of 48-hours to test for leaks.
3. All leaks shall be analyzed and repaired by the Contractor by a method acceptable to the Consultant.
4. The same hydrostatic test shall be performed again after the texture coat has been installed.
5. The cost for repair shall be at the expense of the Contractor.
6. All repairs shall be tested again with the same requirements as the first test, until the problems are remedied and repairs accepted by the Consultant.

3.13 FINISHES

A. Structural Substrate:

1. Provide natural gun finish on all shotcrete, which does not receive texture.
2. Provide Broom Finish on all base layers which are to receive texture coat.
3. Do not scrape or cut to remove high spots until the shotcrete has become stiff enough to withstand pull of the cutting device.

B. Textured and Colored Finish Coat:

1. Provide an expert(s) to perform all texturing, shaping and coloring of the Finish Coat. See also System Description and Quality Assurance in Part One of this Section.
2. Finished product of the finish coat shall simulate natural formations of earth, rock, and vegetation as described in the drawings and photographs and as described under Specific Texture Coat Finishes in Part 4 below.
3. Where finish coat is applied over waterproofing or is otherwise isolated from the structural substrate, provide sufficient depth to allow finish coat to function as a separate structural layer.
4. Extend finish coat finish 18 inches below finish grades.
5. Apply finish coat finish to clean, dampened and sufficiently roughened surfaces.
6. Provide finish coat with approved integral colorant to provide a base color for finish stains.
7. Highlight and contrasting colors will be applied after installation with a medium that is non-toxic, durable and can withstand the environment in which the work is located.
8. Cracks and crevices between rock forms shall be colored darker than the rock surface to accentuate depth and contrast.

3.14 CURING AND PROTECTION

A. Initial Curing: Immediately after placing and finishing, keep each shotcrete installation continuously moist for at least 24 hours. Use one of the following materials or methods:

1. Ponding or continuous sprinkling.
2. Absorptive mat or burlap fabric, sand, or other covering kept continuously wet.
3. Continuous steam (not exceeding 65 C (150 F)) or vapor mist bath.
4. Curing compounds and application. On natural gun or flash finishes, use twice the normal application rate recommended by the manufacturer.
5. Do not use curing compounds on texture coat, structural substrate, which is to receive finish coat, or any surface against which additional shotcrete, color stains, or cementitious finishing materials are to be bonded.
6. Employ positive measures, such as sandblasting, to remove over-sprayed curing compounds completely prior to the application of such additional materials.

B. Final Curing:

1. General: Provide additional curing immediately following the initial curing and before the shotcrete has dried. Continue the method used in initial curing.
2. Formed Surfaces: If forms are removed during curing period, immediately use one of the curing materials or methods listed for initial curing. Continue such curing for the remainder of the curing period.
3. Duration of Curing:
 - a) Continue curing for the first 7-days after shotcrete placement, or for first 3-days if high-early-strength cement is used, or until specified strength is obtained.
 - b) During the curing period, maintain shotcrete above 5C (40F) and in a moist condition as specified for initial curing.
 - c) Prevent rapid drying at the end of the curing period.

3.15 STAINS AND PAINTS

- A. General:
 1. Provide a stained and painted finish to all work of this section.
 2. Employ the approved stains and paints to supplement the specified integral colors to produce the finishes described in Part 4 that follows.
- B. Appurtenances:
 1. Provide a painted finish to all appurtenances that penetrate or are otherwise integrated aesthetically with the artificial rockwork specified in this section.
 2. These include but are not limited to plastic and metal skimmers, exposed wall and pool penetrations, drain covers, electrical boxes and covers, light fixtures, etc.
- C. Application:
 1. Apply coatings so that the appurtenance matches the appearance of the adjacent work of this section.
 2. Camouflage: Coat large appurtenances with a camouflage pattern that assists in disguising the appurtenance
 3. Apply coatings to all portions of the appurtenance including the interior surfaces of pipes and skimmers that are visible from visitor viewing areas.

3.16 FIELD QUALITY CONTROL

- A. Provide additional test panels, as specified for mock-up, during the course of the work as may be requested by the testing agency.

3.17 PROTECTION

- A. Do not permit applied work to damage adjacent surfaces.

PART 4 - SCHEDULE OF FINISHES

4.1 FINISHES

- A. General: The textured and colored finish coat will produce the following finishes as shown on the Drawings. Finishes are to be produced using a special shotcrete mix, sand, earth, cobbles, stains and other materials as necessary to produce realistic simulations of natural earth banks, rock outcrops, boulders, rock fragments, and other forms as specified herein.
- B. Zones of Fidelity:
 1. General: The finish coat may vary in the fidelity of its reproduction of the specified natural rock and earth forms: massing, surface textures, and color detail as specified below.
 2. Three zones of fidelity are required:
 - a) High Fidelity: 0 to 12-feet from visitors,
 - b) Moderate Fidelity: more than 12-feet to 25-feet from visitors or below water surface

- c) Low Fidelity: more than 8m 25-feet from visitors.
- 3. Surface Variation:
 - a) High fidelity zone: provide large and small scale massing, variation in surface textures, depths of cracks, etc. that realistically replicate the massing and surface textures of the natural rock or earth to be replicated.
 - b) Low fidelity zone: provide a simplified version of the natural large scale massing. Simplify the small scale massing and eliminate all three-dimensional surface textures and cracks, providing these depth effects through the use of color to replicate the shadows of three dimensional detail.
 - c) Moderate fidelity zone: provide intermediate detail midway between the High and Low Fidelity, appropriate for the distance from visitors.
- 4. Samples:
- C. Americans with Disabilities Act:
 - 1. Comply with all relevant requirements for ADA.
 - 2. Limit the changes in grade and gaps or 'cracks' in the paving to the maximum allowed by the ADA.
 - 3. Use texture and color to accomplish apparent variation in levels that are not allowed by accessibility codes.
 - 4. Provide non-slip surfaces.
- D. Reference Photos:
 - 1. See also the reference photos on the drawings for information on color, texture, and form.
- E. Surface Performance:
 - 1. Finish Durability: Ensure that all textures and colors will be unaffected when cleaned with pressure washers.
- F. Related Items Included in Rockwork:
 - 1. Provide a painted finish on all Life Support System or other fixtures or items that are included in or adjacent to the artificial rockwork.
 - 2. Comply with all requirements of Section 09 94 16 Themed Finishes.
 - a) Plastic Items: Krylon Fusion Camouflage spray paint or approved alternate.

4.2 SPECIFIC FINISH COAT TEXTURES & COLORS

- A. General:
 - 1. Wadi Beach
 - a) Sample required 3'x3' demonstrating texture and color
 - 2. Wadi Pool - Eroded river bed
 - a) Sample required 3'x3' demonstrating texture and color.
 - 3. Arabian Rock - including: Overhead Animal Transfer, Viewing Shelter cave, Day room rock and back wall
 - a) Rounded, weathered rock at the top and angular edges forms matching the form and textures of the reference images shown on the drawings.
 - b) Provide fragments of natural rock at the base of the artificial rock forms to mimic the natural weathering processes and the effects of gravity on real rock outcrops.
 - c) Match the colors and textures of the natural rock with the colors and textures selected for the artificial rock forms. See reference images in the drawings
 - d) Samples required for each rock formation. 4' X 6' demonstrating texture form and color.

END OF SECTION

SECTION 04 2200 - CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Concrete masonry units.
 - 2. Pre-faced concrete masonry units.
 - 3. Mortar and grout.
 - 4. Steel reinforcing bars.
 - 5. Embedded flashing.
 - 6. Miscellaneous masonry accessories.
 - 7. Masonry-cell fill.
- B. Products Installed but not Furnished under This Section:
 - 1. Cast-stone trim in concrete unit masonry.
- C. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for installing dovetail slots for masonry anchors.

1.2 DEFINITIONS

- A. CMU(s): Concrete masonry unit(s).
- B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Health Product Declaration: For each product.
 - 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer
- C. Shop Drawings: For the following:
 - 1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.
 - 2. Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315.[**Show elevations of reinforced walls.**]
 - 3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.
- D. Samples for Initial Selection:
 - 1. Pre-faced CMUs.
 - 2. Colored mortar.
 - 3. Weep holes/vents.

- E. Samples for Verification: For each type and color of the following:
 - 1. CMUs.
 - 2. Pre-faced CMUs.
 - 3. Pigmented colored-aggregate mortar. Make Samples using same sand and mortar ingredients to be used on Project.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Material Certificates: For each type and size of the following:
 - 1. Masonry units.
 - a. Include **[data on material properties] [material test reports substantiating compliance with requirements]**.
 - b. For masonry units **[used in structural masonry]**, include data and calculations establishing average net-area compressive strength of units.
 - 2. Cementitious materials. Include name of manufacturer, brand name, and type.
 - 3. Mortar admixtures.
 - 4. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
 - 5. Grout mixes. Include description of type and proportions of ingredients.
 - 6. Reinforcing bars.
 - 7. Joint reinforcement.
 - 8. Anchors, ties, and metal accessories.
- C. Mix Designs: For each type of mortar **[and grout]**. Include description of type and proportions of ingredients.
 - 1. Include test reports for mortar mixes required to comply with property specification. Test according to ASTM C 109/C 109M for compressive strength, ASTM C 1506 for water retention, and ASTM C 91/C 91M for air content.
 - 2. Include test reports, according to ASTM C 1019, for grout mixes required to comply with compressive strength requirement.
- D. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to TMS 602/ACI 530.1/ASCE 6.
- E. Cold-Weather **[and Hot-Weather]** Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for testing indicated.
- B. Sample Panels: Build sample panels to verify selections made under Sample submittals and to demonstrate aesthetic effects. Comply with requirements in Section 01 4000 "Quality Requirements" for mockups.

1. Build sample panels for **[each type of exposed unit masonry construction]** **[typical exterior wall]** **[typical interior wall]** **[typical exterior and interior walls]** in sizes approximately **[48 inches (1200 mm)]** **[60 inches (1500 mm)]** **<Insert dimension>** long by **[36 inches (900 mm)]** **[48 inches (1200 mm)]** **<Insert dimension>** high **[by full thickness]**.
 2. Build sample panels facing south.
 3. Where masonry is to match existing, build panels adjacent and parallel to existing surface.
 4. Protect approved sample panels from the elements with weather-resistant membrane.
 5. Approval of sample panels is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; aesthetic qualities of workmanship; and other material and construction qualities specifically approved by Architect in writing.
 - a. Approval of sample panels does not constitute approval of deviations from the Contract Documents contained in sample panels unless Architect specifically approves such deviations in writing.
- C. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
1. Build mockup **[of typical wall area]** as shown on Drawings.
 2. Build mockups for **[each type of exposed unit masonry construction]** **[typical exterior wall]** **[typical interior wall]** **[typical exterior and interior walls]** in sizes approximately **[48 inches (1200 mm)]** **[60 inches (1500 mm)]** **[72 inches (1800 mm)]** **[96 inches (2400 mm)]** **<Insert dimension>** long by **[36 inches (900 mm)]** **[48 inches (1200 mm)]** **[60 inches (1500 mm)]** **[72 inches (1800 mm)]** **<Insert dimension>** high by full thickness, including face and backup wythes and accessories.
 - a. Include a sealant-filled joint at least 16 inches (400 mm) long in **[each]** **[exterior wall]** mockup.
 - b. Include lower corner of window opening at upper corner of exterior wall mockup. Make opening approximately 12 inches (300 mm) wide by 16 inches (400 mm) high.
 - c. Include through-wall flashing installed for a 24-inch (600-mm) length in corner of exterior wall mockup approximately 16 inches (400 mm) down from top of mockup, with a 12-inch (300-mm) length of flashing left exposed to view (omit masonry above half of flashing).
 3. Protect accepted mockups from the elements with weather-resistant membrane.
 4. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Architect in writing.
 - b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- 1.7 DELIVERY, STORAGE, AND HANDLING
- A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

- B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- D. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.
- E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.8 FIELD CONDITIONS

- A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.
 - 1. Extend cover a minimum of 24 inches (600 mm) down both sides of walls, and hold cover securely in place.
- B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.
- C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.
 - 1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 - 4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.
- D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, from single source from single manufacturer for each product required.
- B. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide[**structural**] unit masonry that develops indicated net-area compressive strengths at 28 days.
 - 1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to TMS 602/ACI 530.1/ASCE 6.
 - 2. Determine net-area compressive strength of masonry by testing masonry prisms according to ASTM C 1314.

2.3 UNIT MASONRY, GENERAL

- A. Masonry Standard: Comply with TMS 602/ACI 530.1/ASCE 6 except as modified by requirements in the Contract Documents.
- B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work[**and will be within 20 feet (6 m) vertically and horizontally of a walking surface**].
- C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.
 - 1. Where fire-resistance-rated construction is indicated, units shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction.

2.4 CONCRETE MASONRY UNITS

- A. Regional Materials: CMUs shall be manufactured within 100 miles (160 km) of Project site from aggregates[**and cement**] that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- B. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.
 - 1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
 - 2. Provide [**square-edged**] [**bullnose**] units for outside corners unless otherwise indicated.
- C. CMUs: ASTM C 90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of .
 2. Density Classification: Normal weight.
 3. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less-than-nominal dimensions.
 4. Exposed Faces: Provide color and texture matching the range represented by Architect's sample.
 5. Faces To Receive Plaster: Where units are indicated to receive a direct application of plaster, provide textured-face units made with gap-graded aggregates.
- D. Pre-faced CMUs: Lightweight hollow concrete units complying with ASTM C 90, with manufacturer's standard smooth resinous facing complying with ASTM C 744.
1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. **<Insert, in separate subparagraphs, manufacturer's name; product name or designation>.**
 2. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of .
 3. Size: Manufactured to dimensions specified in "CMUs" Paragraph but with pre-faced surfaces having 1/16-inch- (1.5-mm-) wide returns of facing to create 1/4-inch- (6.5-mm-) wide mortar joints with modular coursing.
 4. Colors and Patterns: **[As indicated by manufacturer's designations] [Match Architect's samples] [As selected by Architect from manufacturer's full range].**
- 2.5 CONCRETE LINTELS
- A. General: Provide one of the following:
- B. Concrete Lintels: ASTM C 1623, matching CMUs in color, texture, and density classification; and with reinforcing bars indicated. **[Provide lintels with net-area compressive strength not less than that of CMUs.]**
- 2.6 MORTAR AND GROUT MATERIALS
- A. Regional Materials: Aggregate for mortar and grout[, **cement, and lime**] shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- B. Portland Cement: ASTM C 150/C 150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.
1. Alkali content shall not be more than 0.1 percent when tested according to ASTM C 114.
- C. Hydrated Lime: ASTM C 207, Type S.
- D. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
- E. Masonry Cement: ASTM C 91/C 91M.

1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Cemex S.A.B. de C.V.; Brikset, Type N Citadel, Type S Dixie, Type S Kosmortar, Type N Richmortar Victor Plastic Cement.
 - b. Essroc, Italcementi Group; Brixment Flamingo Color Masonry Cement Velvet.
 - c. Holcim (US) Inc.; Mortamix Masonry Cement Rainbow Mortamix Custom Buff Masonry Cement White Mortamix Masonry Cement.
 - d. Lafarge North America Inc.; Magnolia Masonry Cement Lafarge Masonry Cement Trinity White Masonry Cement.
 - e. Lehigh Cement Company.; Lehigh Masonry Cement Lehigh White Masonry Cement.

- F. Mortar Cement: ASTM C 1329/C 1329M.
 1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Lafarge North America Inc.; Lafarge Mortar Cement Magnolia Superbond Mortar Cement.

- G. Mortar Pigments: Natural and synthetic iron oxides and chromium oxides, compounded for use in mortar mixes and complying with ASTM C 979/C 979M. Use only pigments with a record of satisfactory performance in masonry mortar.
 1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Davis Colors; True Tone Mortar Colors.
 - b. Lanxess Corporation; Bayferrox Iron Oxide Pigments.
 - c. Solomon Colors, Inc.; SGS Mortar Colors.

- H. Colored Cement Products: Packaged blend made from portland cement and hydrated lime masonry cement or and mortar pigments, all complying with specified requirements, and containing no other ingredients.
 1. Colored Portland Cement-Lime Mix:
 - a. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Essroc, Italcementi Group; Riverton Portland Cement Lime Custom Color.
 - 2) Holcim (US) Inc.; Rainbow Mortamix Custom Color Cement/Lime.
 - 3) Lafarge North America Inc.; Eaglebond Portland & Lime.
 - 4) Lehigh Cement Company.; Lehigh Custom Color Portland/Lime Cement.
 2. Colored Masonry Cement:
 - a. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Cemex S.A.B. de C.V.; Richcolor Masonry Cement.
 - 2) Essroc, Italcementi Group; Brixment-in-Color Flamingo Color Masonry Cement.
 - 3) Holcim (US) Inc.; Rainbow Mortamix Custom Color Masonry Cement.
 - 4) Lafarge North America Inc.; U.S. Cement Custom Color Masonry Cement.
 - 5) Lehigh Cement Company.; Lehigh Custom Color Masonry Cement.

3. Formulate blend as required to produce color indicated or, if not indicated, as selected from manufacturer's standard colors.
 4. Pigments shall not exceed 10 percent of portland cement by weight.
 5. Pigments shall not exceed 5 percent of [masonry cement] [or] [mortar cement] by weight.
- I. Aggregate for Mortar: ASTM C 144.
1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
 2. For joints less than 1/4 inch (6 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.
 3. White-Mortar Aggregates: Natural white sand or crushed white stone.
 4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.
- J. Aggregate for Grout: ASTM C 404.
- K. Epoxy Pointing Mortar: ASTM C 395, epoxy-resin-based material formulated for use as pointing mortar for glazed or pre-faced masonry units (and approved for such use by manufacturer of units); in color indicated or, if not otherwise indicated, as selected by Architect from manufacturer's colors.
- L. Water: Potable.
- 2.7 REINFORCEMENT
- A. Uncoated Steel Reinforcing Bars: ASTM A 615/A 615M or ASTM A 996/A 996M, Grade 60 (Grade 420).
- B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.
1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Heckmann Building Products Inc.; No. 376 Rebar Positioner.
 - b. Hohmann & Barnard, Inc.; #RB or #RB-Twin Rebar Positioner.
 - c. Wire-Bond; O-Ring or Double O-Ring Rebar Positioner.
- 2.8 TIES AND ANCHORS
- A. General: Ties and anchors shall extend at least 1-1/2 inches (38 mm) into masonry but with at least a 5/8-inch (16-mm) cover on outside face.
- B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
1. Mill-Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M, with ASTM A 641/A 641M, Class 1 coating.
 2. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82/A 82M, with ASTM A 153/A 153M, Class B-2 coating.

3. Stainless-Steel Wire: ASTM A 580/A 580M, [Type 304] [Type 316].
 4. Galvanized-Steel Sheet: ASTM A 653/A 653M, Commercial Steel, G60 (Z180) zinc coating.
 5. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.
 6. Stainless-Steel Sheet: ASTM A 240/A 240M or ASTM A 666, [Type 304] [Type 316].
 7. Steel Plates, Shapes, and Bars: ASTM A 36/A 36M.
- C. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.
1. Connector Section: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from [0.060-inch- (1.52-mm-) **thick steel sheet, galvanized after fabrication**] [0.105-inch- (2.66-mm-) **thick steel sheet, galvanized after fabrication**] [0.062-inch- (1.59-mm-) **thick, stainless-steel sheet**] [0.109-inch- (2.78-mm-) **thick, stainless-steel sheet**].
 - a. [0.064-inch- (1.63-mm-)] [0.108-inch- (2.74-mm-)] thick, galvanized-steel sheet may be used at interior walls unless otherwise indicated.
 2. Tie Section: Triangular-shaped wire tie made from [0.187-inch- (4.76-mm-)] [0.25-inch- (6.35-mm-)] diameter, [**hot-dip galvanized steel**] [**stainless-steel**] wire. [**Mill-galvanized wire may be used at interior walls unless otherwise indicated.**]
 3. Corrugated-Metal Ties: Metal strips not less than 7/8 inch (22 mm) wide with corrugations having a wavelength of 0.3 to 0.5 inch (7.6 to 12.7 mm) and an amplitude of 0.06 to 0.10 inch (1.5 to 2.5 mm) made from [0.060-inch- (1.52-mm-) **thick steel sheet, galvanized after fabrication**] [0.075-inch- (1.90 mm-) **thick steel sheet, galvanized after fabrication**] [0.105-inch- (2.66-mm-) **thick steel sheet, galvanized after fabrication**] [0.062-inch- (1.59-mm-) **thick, stainless-steel sheet**] [0.078-inch- (1.98-mm-) **thick, stainless-steel sheet**] [0.109-inch- (2.78-mm-) **thick, stainless-steel sheet**] with dovetail tabs for inserting into dovetail slots in concrete.
 - a. [0.064-inch- (1.63-mm-)] [0.079-inch- (2.01-mm-)] [0.108-inch- (2.74-mm-)] thick, galvanized sheet may be used at interior walls unless otherwise indicated.
- D. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (9.5-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from [**steel, hot-dip galvanized after fabrication**] [**stainless steel**].

2.9 EMBEDDED FLASHING MATERIALS

- A. Masonry flashing shall be metal, except as otherwise noted. Metal flashing shall be through-wall, where feasible, except where otherwise clearly shown or noted. Through-wall flashing shall be 2-piece, except where otherwise clearly shown or noted.
- B. Metal Flashing: Provide metal flashing complying with [SMACNA's "Architectural Sheet Metal Manual"] [Section 07 6200 "Sheet Metal Flashing and Trim"] and as follows:
1. Stainless Steel: ASTM A 240/A 240M or ASTM A 666, Type 304, 0.016 inch (0.40 mm) thick.
 2. Fabricate continuous flashings in sections 96 inches (2400 mm) long minimum, but not exceeding 12 feet (3.7 m). Provide splice plates at joints of formed, smooth metal flashing.
 3. Fabricate through-wall metal flashing embedded in masonry from stainless steel, with ribs at 3-inch (76-mm) intervals along length of flashing to provide an integral mortar bond.

- a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Cheney Flashing Company; Cheney Flashing (Dovetail) Cheney 3-Way Flashing (Sawtooth).
 - 2) Keystone Flashing Company, Inc.; Keystone 3-Way Interlocking Thruwall Flashing.
 4. Fabricate through-wall flashing with snaplock receiver on exterior face where indicated to receive counterflashing.
 5. Fabricate through-wall flashing with drip edge **[where]** **[unless otherwise]** indicated. Fabricate by extending flashing 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees **[and hemmed]**.
 6. Fabricate through-wall flashing with sealant stop **[where]** **[unless otherwise]** indicated. Fabricate by bending metal back on itself 3/4 inch (19 mm) at exterior face of wall and down into joint 1/4 inch (6 mm) to form a stop for retaining sealant backer rod.
 7. Fabricate metal **[drip edges]** **[and]** **[sealant stops]** for ribbed metal flashing from plain metal flashing of same metal as ribbed flashing and extending at least 3 inches (76 mm) into wall with hemmed inner edge to receive ribbed flashing and form a hooked seam. Form hem on upper surface of metal so that completed seam sheds water.
 8. Fabricate metal drip edges from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees **[and hemmed]**.
 9. Fabricate metal sealant stops from stainless steel. Extend at least 3 inches (76 mm) into wall and out to exterior face of wall. At exterior face of wall, bend metal back on itself for 3/4 inch (19 mm) and down into joint 1/4 inch (6 mm) to form a stop for retaining sealant backer rod.
 10. Fabricate metal expansion-joint strips from **[stainless steel]** **[copper]** to shapes indicated.
 11. Solder metal items at corners.
- C. Flexible Flashing: Use **[one of]** the following unless otherwise indicated:
1. Copper-Laminated Flashing: [5-oz./sq. ft. (1.5-kg/sq. m)] [7-oz./sq. ft. (2-kg/sq. m)] copper sheet bonded between two layers of glass-fiber cloth. Use only where flashing is fully concealed in masonry.
 - a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Advanced Building Products Inc.; Copper Fabric Flashing Copper Sealtite 2000.
 - 2) Hohmann & Barnard, Inc.; Copper Fabric Flashing.
 - 3) York Manufacturing, Inc.; Multi-Flash 500.
 2. Asphalt-Coated Copper Flashing: [5-oz./sq. ft. (1.5-kg/sq. m)] [7-oz./sq. ft. (2-kg/sq. m)] copper sheet coated with flexible asphalt. Use only where flashing is fully concealed in masonry.
 - a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Advanced Building Products Inc.; Cop-R-Cote.
 - 2) Hohmann & Barnard, Inc.; Coated Copper Flashing.

3. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than [0.030 inch (0.76 mm)] [0.040 inch (1.02 mm)].
 - a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Advanced Building Products Inc.; Peel-N-Seal.
 - 2) Carlisle Coatings & Waterproofing; CCW-705-TWF Thru-Wall Flashing.
 - 3) Fiberweb, Clark Hammerbeam Corp.; Aquaflash 500.
 - 4) GCP Applied Technologies; Perm-A-Barrier Wall Flashing.
 - 5) Heckmann Building Products Inc.; No. 82 Rubberized-Asphalt Thru-Wall Flashing.
 - 6) Hohmann & Barnard, Inc.; Sando-Seal.
 - 7) Polyguard Products, Inc.; Polyguard 300 Polyguard 400.
 - 8) W. R. Meadows, Inc.; Air-Shield Thru-Wall Flashing.
 - 9) Williams Products, Inc.; Everlastic MF-40.
 - b. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.
4. Butyl Rubber Flashing: Composite, self-adhesive, flashing product consisting of a pliable, butyl rubber compound, bonded to a high-density polyethylene film, aluminum foil, or spunbonded polyolefin to produce an overall thickness of not less than [0.030 inch (0.76 mm)] [0.040 inch (1.02 mm)]. GCP Applied Technologies
 - a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) DuPont Building Innovations; E. I. du Pont de Nemours and Company; DuPont Flashing Tape.
 - 2) GCP Applied Technologies; Vycor Butyl Self Adhered Flashing.
 - 3) Protecto Wrap Company; BT-25 XL.
 - 4) Raven Industries Inc.; Fortress Flashshield.
 - b. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.
5. Elastomeric Thermoplastic Flashing: Composite flashing product consisting of a polyester-reinforced ethylene interpolymer alloy.
 - a. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) DuPont (E. I. du Pont de Nemours and Company); Thru-Wall Flashing.
 - 2) Hohmann & Barnard, Inc.; Flex-Flash.
 - 3) Hyload, Inc.; Hyload Cloaked Flashing System.
 - 4) Mortar Net USA, Ltd.; Total Flash.
 - b. Monolithic Sheet: Elastomeric thermoplastic flashing, 0.040 inch (1.02 mm) thick.
 - c. Self-Adhesive Sheet: Elastomeric thermoplastic flashing, 0.025 inch (0.64 mm) thick, with a 0.015-inch- (0.38-mm-) thick coating of adhesive.
 - d. Self-Adhesive Sheet with Drip Edge: Elastomeric thermoplastic flashing, 0.025 inch (0.64 mm) thick, with a 0.015-inch- (0.38-mm-) thick coating of rubberized-asphalt adhesive. Where flashing extends to face of masonry, rubberized-asphalt coating is held back approximately 1-1/2 inches (38 mm) from edge.

- 1) Color: **[Gray] [White] [Tan/buff] [Black]**.
- e. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.
6. EPDM Flashing: Sheet flashing product made from ethylene-propylene-diene terpolymer, complying with ASTM D 4637/D 4637M, 0.040 inch (1.02 mm) thick.
 - a. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - 1) Carlisle Coatings & Waterproofing; Pre-Kleened EPDM Thru-Wall Flashing.
 - 2) Firestone Specialty Products; FlashGuard.
 - 3) Heckmann Building Products Inc.; No. 81 EPDM Thru-Wall Flashing.
 - 4) Hohmann & Barnard, Inc.; EPDM Flashing.
- D. Application: Unless otherwise indicated, use the following:
 1. Where flashing is indicated to receive counterflashing, use metal flashing.
 2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.
 3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing **[with a drip edge] [with a sealant stop] [or flexible flashing with a metal drip edge] [or elastomeric thermoplastic flashing with a drip edge] [or flexible flashing with a metal sealant stop]**.
 4. Where flashing is fully concealed, use **[metal flashing] [or] [flexible flashing]**.
- E. Single-Wythe CMU Flashing System: System of CMU cell flashing pans and interlocking CMU web covers made from UV-resistant, high-density polyethylene. Cell flashing pans have integral weep spouts designed to be built into mortar bed joints and that extend into the cell to prevent clogging with mortar.
 1. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]**:
 - a. Mortar Net USA, Ltd.; Blok-Flash.
- F. Solder and Sealants for Sheet Metal Flashings: **[As specified in Section 07 6200 "Sheet Metal Flashing and Trim."]**
 1. Solder for Stainless Steel: ASTM B 32, **[Grade Sn60] [Grade Sn96]**, with acid flux of type recommended by stainless-steel sheet manufacturer.
 2. Solder for Copper: ASTM B 32, **[Grade Sn50] [with maximum lead content of 0.2 percent]**.
 3. Elastomeric Sealant: ASTM C 920, chemically curing **[urethane] [polysulfide] [silicone]** sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and remain watertight.
- G. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.10 MISCELLANEOUS MASONRY ACCESSORIES

- A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene urethane or.
- B. Preformed Control-Joint Gaskets: Made from **[styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805] [or] [PVC, complying with ASTM D 2287, Type PVC-65406]** and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.
- C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D 226/D 226M, Type I (No. 15 asphalt felt).

2.11 MASONRY-CELL FILL

- A. Loose-Fill Insulation: Perlite complying with ASTM C 549, Type II (surface treated for water repellency and limited moisture absorption) or Type IV (surface treated for water repellency and to limit dust generation).
- B. Lightweight-Aggregate Fill: ASTM C 331/C 331M.

2.12 MORTAR AND GROUT MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.
 - 1. Do not use calcium chloride in mortar or grout.
 - 2. Use portland cement-lime masonry cement or mortar unless otherwise indicated.
 - 3. For exterior masonry, use portland cement-lime masonry cement or mortar.
 - 4. For reinforced masonry, use portland cement-lime masonry cement mortar cement mortar.
 - 5. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
- B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
- C. Mortar for Unit Masonry: Comply with ASTM C 270, **[Proportion] [Property]** Specification. Provide the following types of mortar for applications stated unless another type is indicated **[or needed to provide required compressive strength of masonry]**.
 - 1. For masonry below grade or in contact with earth, use **[Type M] [Type S]**.
 - 2. For reinforced masonry, use **[Type S] [Type N]**.
 - 3. For mortar parge coats, use **[Type S] [or] [Type N]**.
 - 4. For exterior, above-grade, load-bearing and nonload-bearing walls and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.
 - 5. For interior nonload-bearing partitions, Type O may be used instead of Type N.

- D. Pigmented Mortar: Use colored cement product[**or select and proportion pigments with other ingredients to produce color required. Do not add pigments to colored cement products**].
1. Pigments shall not exceed 10 percent of portland cement by weight.
 2. Pigments shall not exceed 5 percent of **[masonry cement]** **[or]** **[mortar cement]** by weight.
 3. Mix to match Architect's sample.
 4. Application: Use pigmented mortar for exposed mortar joints with the following units:
 - a. Pre-faced CMUs.
 - b. Cast-stone trim units.
- E. Colored-Aggregate Mortar: Produce required mortar color by using colored aggregates and natural color or white cement as necessary to produce required mortar color.
1. Mix to match Architect's sample.
 2. Application: Use colored-aggregate mortar for exposed mortar joints with the following units:
 - a. Pre-faced CMUs.
 - b. Cast-stone trim units.
- F. Grout for Unit Masonry: Comply with ASTM C 476.
1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602/ACI 530.1/ASCE 6 for dimensions of grout spaces and pour height.
 2. Proportion grout in accordance with ASTM C 476, **[Table 1]** **[or]** **[paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi (14 MPa)]**.
 3. Provide grout with a slump of [8 to 11 inches (200 to 280 mm)] [10 to 11 inches (250 to 280 mm)] as measured according to ASTM C 143/C 143M.
- G. Epoxy Pointing Mortar: Mix epoxy pointing mortar to comply with mortar manufacturer's written instructions.
1. Application: Use epoxy pointing mortar for exposed mortar joints with pre-faced CMUs.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
 2. Verify that foundations are within tolerances specified.
 3. Verify that reinforcing dowels are properly placed.
 4. Verify that substrates are free of substances that would impair mortar bond.
- B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Build chases and recesses to accommodate items specified in this and other Sections.
- B. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.
- C. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

3.3 TOLERANCES

- A. Dimensions and Locations of Elements:
 - 1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (12 mm) or minus 1/4 inch (6 mm).
 - 2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (12 mm).
 - 3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (12 mm) total.
- B. Lines and Levels:
 - 1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
 - 2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2-inch (12-mm) maximum.
 - 6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2-inch (12-mm) maximum.
 - 7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm).
- C. Joints:
 - 1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).
 - 2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
 - 3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
 - 4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm).

3.4 LAYING MASONRY WALLS

- A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.
- B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in **[running bond]** **[bond pattern indicated on Drawings]**; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners, jambs or other penetrations.
- C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than [2 inches (50 mm)] [4 inches (100 mm)]. Bond and interlock each course of each wythe at corners. Do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners, jambs or other penetrations.
- D. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.
- E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.
- F. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.
- G. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.
- H. Fill cores in hollow CMUs with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.
- I. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.
 - 1. Install compressible filler in joint between top of partition and underside of structure above.
 - 2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors [48 inches (1200 mm)] **<Insert spacing>** o.c. unless otherwise indicated.
 - 3. Wedge nonload-bearing partitions against structure above with small pieces of tile, slate, or metal. Fill joint with mortar after dead-load deflection of structure above approaches final position.
 - 4. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 07 8443 "Joint Firestopping."

3.5 MORTAR BEDDING AND JOINTING

- A. Lay hollow CMUs as follows:

1. Bed face shells in mortar and make head joints of depth equal to bed joints.
 2. Bed webs in mortar in all courses of piers, columns, and pilasters.
 3. Bed webs in mortar in grouted masonry, including starting course on footings.
 4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
- B. Set cast-stone trim units in full bed of mortar with full vertical joints. Fill dowel, anchor, and similar holes.
1. Clean soiled surfaces with fiber brush and soap powder and rinse thoroughly with clear water.
 2. Wet joint surfaces thoroughly before applying mortar.
 3. Rake out mortar joints for pointing with sealant.
- C. Rake out mortar joints at pre-faced CMUs to a uniform depth of 1/4 inch (6 mm) and point with epoxy mortar to comply with epoxy-mortar manufacturer's written instructions.
- D. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.
- E. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.
- F. Cut joints flush where indicated to receive air barriers, dampproofing or waterproofing unless otherwise indicated.

3.6 MASONRY-CELL FILL

- A. Pour loose-fill insulation lightweight-aggregate fill into cavities to fill void spaces. Maintain inspection ports to show presence of fill at extremities of each pour area. Close the ports after filling has been confirmed. Limit the fall of fill to one story high, but not more than 20 feet (6 m).
- B. Install molded-polystyrene insulation units into masonry unit cells before laying units.

3.7 MASONRY-JOINT REINFORCEMENT

- A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).
1. Space reinforcement not more than 16 inches (406 mm) o.c.
 2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
 3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings[**in addition to continuous reinforcement**].
- B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.
- C. Provide continuity at wall intersections by using prefabricated T-shaped units.
- D. Provide continuity at corners by using prefabricated L-shaped units.

- E. Cut and bend reinforcing units as directed by manufacturer for continuity at[**corners,**] returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.8 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

- A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:
 - 1. Provide an open space not less than [1/2 inch (13 mm)] [1 inch (25 mm)] [2 inches (50 mm)] wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
 - 2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
 - 3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

3.9 CONTROL AND EXPANSION JOINTS

- A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.
- B. Form control joints in concrete masonry [**as follows**] [**using one of the following methods**]:
 - 1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout, and rake out joints in exposed faces for application of sealant.
 - 2. Install preformed control-joint gaskets designed to fit standard sash block.
 - 3. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar, or rake out joint for application of sealant.
 - 4. Install temporary foam-plastic filler in head joints, and remove filler when unit masonry is complete for application of sealant.

3.10 LINTELS

- A. Provide concrete lintels where shown and where openings of more than 12 inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels.
- B. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.

3.11 FLASHING

- A. General: Install embedded flashing at ledges and other obstructions to downward flow of water in wall where indicated.
- B. Install flashing as follows unless otherwise indicated:
 - 1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape[**as recommended by flashing manufacturer**].

2. At lintels, extend flashing a minimum of 6 inches (150 mm) into masonry at each end. At heads and sills, extend flashing 6 inches (150 mm) at ends and turn up not less than 2 inches (50 mm) to form end dams.
 3. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 07 9200 "Joint Sealants" for application indicated.
 4. Install metal [**drip edges**] [**and**] [**sealant stops**] with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 07 9200 "Joint Sealants" for application indicated.
 5. Install metal drip edges beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal drip edge.
 6. Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal flashing termination.
 7. Cut flexible flashing off flush with face of wall after masonry wall construction is completed.
- C. Install single-wythe CMU flashing system in bed joints of CMU walls where indicated to comply with manufacturer's written instructions. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.
- D. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.
- 3.12 REINFORCED UNIT MASONRY INSTALLATION
- A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.
1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
 2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.
- B. Placing Reinforcement: Comply with requirements in TMS 602/ACI 530.1/ASCE 6.
- C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.
1. Comply with requirements in TMS 602/ACI 530.1/ASCE 6 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
 2. Limit height of vertical grout pours to not more than [60 inches (1520 mm)] [12.67 ft. (3.86 m)] <Insert height>.

3.13 FIELD QUALITY CONTROL

- A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.
- B. Inspections: Special inspections according to Level [B] [C] in TMS 402/ACI 530/ASCE 5.
 - 1. Begin masonry construction only after inspectors have verified proportions of site-prepared mortar.
 - 2. Place grout only after inspectors have verified compliance of grout spaces and of grades, sizes, and locations of reinforcement.
 - 3. Place grout only after inspectors have verified proportions of site-prepared grout.
- C. Testing Prior to Construction: One set of tests.
- D. Testing Frequency: One set of tests for each 5000 sq. ft. (464 sq. m) of wall area or portion thereof.
- E. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.
- F. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.
- G. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for [mortar air content] [and] [compressive strength].
- H. Grout Test (Compressive Strength): For each mix provided, according to ASTM C 1019.
- I. Prism Test: For each type of construction provided, according to ASTM C 1314 at [7 days and at]28 days.

3.14 PARGING

- A. Parge exterior faces of below-grade masonry walls, where indicated, in two uniform coats to a total thickness of 3/4 inch (19 mm). Dampen wall before applying first coat, and scarify first coat to ensure full bond to subsequent coat.
- B. If recommended by fluid-applied air barrier manufacturer, parge exterior faces of CMU and cast-in-place concrete surfaces indicated to receive air barrier. Apply in thickness as recommended by air barrier manufacturer. Dampen wall before applying.
- C. Use a steel-trowel finish to produce a smooth, flat, dense surface with a maximum surface variation of 1/8 inch per foot (3 mm per 300 mm). Form a wash at top of parging and a cove at bottom.
- D. Damp-cure parging for at least 24 hours and protect parging until cured.

3.15 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.
- B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.
- C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.
- D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:
 - 1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 - 2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
 - 3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
 - 4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
 - 5. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.

3.16 MASONRY WASTE DISPOSAL

- A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.
- B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.
 - 1. Crush masonry waste to less than 4 inches (100 mm) in each dimension.
 - 2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Section 31 2000 "Earth Moving."
 - 3. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.
- C. Masonry Waste Recycling: Return broken CMUs not used as fill to manufacturer for recycling.
- D. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION

SECTION 04 4313.13 - ANCHORED STONE MASONRY VENEER**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Stone masonry anchored to concrete backup.
 - 2. Stone masonry anchored to unit masonry backup.
- B. Products Installed but Not Furnished under This Section Include:
 - 1. Steel lintels in unit masonry.
 - 2. Steel shelf angles for supporting unit masonry.
- C. Related Requirements:
 - 1. Section 04 2000 "Unit Masonry" for **[concealed flashing] [horizontal joint reinforcement] [and] [veneer anchors]**.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each variety of stone, stone accessory, and manufactured product.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration (EPD): For each product.
 - 2. Environmental Product Declaration: For each product.
 - 3. Third-Party Certifications: For each product.
 - 4. Third-Party Certified Life Cycle Assessment: For each product.
- C. Samples for Initial Selection: For colored mortar and other items involving color selection.
- D. Samples for Verification:
 - 1. For each stone type indicated. Include at least **[two] [three] [four] [five]** <Insert **number**> Samples in each set and show the full range of color and other visual characteristics in completed Work.
 - 2. For each color of mortar required. **[Label Samples to indicate types and amounts of pigments used.]**

1.4 INFORMATIONAL SUBMITTALS

- A. Sealant Compatibility and Adhesion Test Report: From sealant manufacturer indicating that sealants will not stain or damage stone. Include interpretation of test results and recommendations for primers and substrate preparation needed for adhesion.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified installer who employs experienced stonemasons and stone fitters.

- B. Mockups: Build mockups to demonstrate aesthetic effects and to set quality standards for materials and execution.
1. Build mockup of typical wall area as shown on Drawings.
 2. Build mockups for **[each type of stone masonry]** **[typical exterior wall]** in sizes approximately **[48 inches (1200 mm)]** **[60 inches (1500 mm)]** **[72 inches (1800 mm)]** **[96 inches (2400 mm)]** **<Insert dimension>** long by **[48 inches (1200 mm)]** **[60 inches (1500 mm)]** **[72 inches (1800 mm)]** **<Insert dimension>** high by full thickness, including face and backup wythes and accessories.
 - a. Include stone coping at top of mockup.
 - b. Include a sealant-filled joint at least 16 inches (400 mm) long in mockup.
 - c. Include through-wall flashing installed for a 24-inch (600-mm) length in corner of mockup approximately 16 inches (400 mm) down from top of mockup, with a 12-inch (300-mm) length of flashing left exposed to view (omit stone masonry above half of flashing).
 - d. Include **[metal]** **[wood]** studs, sheathing, veneer anchors, flashing, and weep holes in exterior masonry-veneer wall mockup.
 3. Protect accepted mockups from the elements with weather-resistant membrane.
 4. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. Provide the following upon request:
1. Qualification Data: For Installer.
 2. List of Materials Used in Constructing Mockups: List generic product names together with manufacturers, manufacturers' product names, supply sources, and other information as required to identify materials used. Include mix proportions for mortar and source of aggregates.
 - a. Neither receipt of list nor approval of mockups constitutes approval of deviations from the Contract Documents contained in mockups unless Architect approves such deviations in writing.
 3. Material Test Reports:
 - a. Stone Test Reports: For **[each]** stone variety proposed for use on Project, by a qualified testing agency, indicating compliance with required physical properties, other than abrasion resistance, according to referenced ASTM standards. Base reports on testing done within previous **[three]** **[five]** **<Insert number>** years.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Sealant Compatibility and Adhesion Testing: Submit to joint-sealant manufacturers, for compatibility and adhesion testing according to sealant manufacturer's standard testing methods and Section 07 9200 "Joint Sealants," Samples of materials that will contact or affect joint sealants.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

- B. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
- C. Deliver preblended, dry mortar mix in moisture-resistant containers designed for use with dispensing silos. Store preblended, dry mortar mix in delivery containers on elevated platforms, under cover, in a dry location, or in covered weatherproof dispensing silos.
- D. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.8 FIELD CONDITIONS

- A. Protection of Stone Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed stone masonry when construction is not in progress.
 - 1. Extend cover a minimum of 24 inches (600 mm) down both sides and hold cover securely in place.
- B. Stain Prevention: Immediately remove mortar and soil to prevent them from staining stone masonry face.
 - 1. Protect base of walls from rain-splashed mud and mortar splatter using coverings spread on the ground and over the wall surface.
 - 2. Protect sills, ledges, and projections from mortar droppings.
 - 3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
 - 4. Turn scaffold boards near the wall on edge at end of each day to prevent rain from splashing mortar and dirt on completed stone masonry.
- C. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace stone masonry damaged by frost or freezing conditions. Comply with cold-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.
 - 1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and above and will remain so until masonry has dried, but not less than seven days after completing cleaning.
- D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602/ACI 530.1/ASCE 6.

1.9 COORDINATION

- A. Advise installers of adjacent Work about specific requirements for placement of reinforcement, veneer anchors, flashing, and similar items to be built into stone masonry.
- B. Coordinate locations of dovetail slots installed in concrete that are to receive stone anchors.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from single quarry, whether specified in this Section or in another Section of the Specifications, with resources to provide materials of consistent quality in appearance and physical properties.
- B. Source Limitations for Mortar Materials: Obtain mortar ingredients of uniform quality for each cementitious component from single manufacturer and each aggregate from single source or producer.
- C. Varieties and Sources: Subject to compliance with requirements, provide stone of varieties and from sources complying with Section 04 4200 "Exterior Stone Cladding."

2.2 QUARTZ-BASED STONE

- A. Material Standard: Comply with ASTM C616/C616M, Classification III Quartzite.
- B. Regional Materials: Stone shall be fabricated within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered within 100 miles (160 km) of Project site.
- C. Varieties and Sources: Subject to compliance with requirements, provide the following:
 - 1. Tri-State Stone and Building Supply.
 - a. Carderock Ashlar - Brown tones.
- D. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.

2.3 MORTAR MATERIALS

- A. Regional Materials: Aggregate for mortar and grout, cement, and lime shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- B. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Essroc.
 - b. Holcim (US) Inc.
 - c. Lafarge North America Inc.
 - d. Lehigh Hanson; HeidelbergCement Group.
 - e. Mutual Materials Co.
- C. Aggregate: ASTM C144 and as follows:
 - 1. For pointing mortar, use aggregate graded with 100 percent passing No. 16 (1.18-mm) sieve.

2. Colored Aggregates: Natural-colored sand or ground marble, granite, or other sound stone; of color necessary to produce required mortar color.
 - a. Match Architect's sample.

D. Water: Potable.

2.4 VENEER ANCHORS

- A. Size: Sufficient to extend at least halfway, but not less than 1-1/2 inches (38 mm), through stone masonry and with at least a 5/8-inch (16-mm) cover on exterior face.
- B. Adjustable Masonry-Veneer Anchors:
 1. General: Provide anchors that allow vertical adjustment but resist a 100-lbf (445-N) load in both tension and compression perpendicular to plane of wall without deforming or developing play in excess of 1/16 inch (1.5 mm).
 2. Fabricate sheet metal anchor sections and other sheet metal parts from [0.075-inch- (1.90-mm-) **thick steel sheet, galvanized after fabrication**] [0.105-inch- (2.66-mm-) **thick steel sheet, galvanized after fabrication**] [0.078-inch- (1.98-mm-) **thick, stainless steel sheet**] [0.109-inch- (2.78-mm-) **thick, stainless steel sheet**].
 3. Fabricate wire ties from [0.187-inch- (4.76-mm-)] [0.25-inch- (6.35-mm-)] diameter, [**hot-dip galvanized-steel**] [**stainless steel**] wire unless otherwise indicated.
 4. Fabricate wire connector sections from [0.187-inch- (4.76-mm-)] [0.25-inch- (6.35-mm-)] diameter, [**hot-dip galvanized-steel**] [**stainless steel**] wire.
 5. Contractor's Option: Unless otherwise indicated, provide any of the adjustable masonry-veneer anchors specified.

2.5 STONE TRIM ANCHORS

- A. Stone Trim Anchors: Units fabricated with tabs or dowels designed to engage kerfs or holes in stone trim units and holes for fasteners or postinstalled anchor bolts for fastening to substrates or framing as indicated.
 1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. Canaren Inc.
 - b. Heckmann Building Products, Inc.
 - c. Hohmann & Barnard, Inc.
 - d. Meadow Burke.
- B. Materials: Fabricate anchors from stainless steel, ASTM A240/A240M or ASTM A666, Type 304 Type 316. Fabricate dowels from stainless steel, ASTM A276, Type 304 Type 316.
- C. Fasteners for Stone Trim Anchors: Annealed stainless steel bolts, nuts, and washers; ASTM F593 (ASTM F738M) for bolts and ASTM F594 (ASTM F836M) for nuts, Alloy Group 1 (A1).

- D. Postinstalled Anchor Bolts for Fastening Stone Trim Anchors: Chemical anchors torque-controlled expansion anchors undercut anchors made from stainless steel components complying with ASTM F593 and ASTM F594, Alloy Group 1 or 2 (ASTM F738M and ASTM F836M, Alloy Group A1 or A4) for bolts and nuts; ASTM A666 or ASTM A276, Type 304 or Type 316, for anchors.

2.6 EMBEDDED FLASHING MATERIALS

- A. Metal Flashing: Provide metal flashing, where flashing is exposed or partly exposed and where indicated, complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:
1. Copper: ASTM B370, Temper H00 or H01, cold-rolled copper sheet, 10-oz./sq. ft. (3-kg/sq. m) weight or 0.0135 inch (0.34 mm) thick for fully concealed flashing; 16-oz./sq. ft. (5-kg/sq. m) weight or 0.0216 inch (0.55 mm) thick elsewhere.
 2. Fabricate continuous flashings in sections 96 inches (2400 mm) long minimum, but not exceeding 12 feet (3.6 m). Provide splice plates at joints of formed, smooth metal flashing.
 3. Fabricate through-wall metal flashing embedded in masonry from **[stainless steel]** **[copper]**, with ribs at 3-inch (75-mm) intervals along length of flashing to provide an integral mortar bond.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following]** **[provide products by one of the following]** **[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Cheney Flashing Company.
 - 2) Hohmann & Barnard, Inc.
 - 3) Keystone Flashing Company, Inc.
 4. Fabricate through-wall flashing with snaplock receiver on exterior face where indicated to receive counterflashing.
 5. Fabricate through-wall flashing with drip edge **[where]** **[unless otherwise]** indicated. Fabricate by extending flashing 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees **[and hemmed]**.
 6. Fabricate through-wall flashing with sealant stop **[where]** **[unless otherwise]** indicated. Fabricate by bending metal back on itself 3/4 inch (19 mm) at exterior wall face and down into joint 3/8 inch (10 mm) to form a stop for retaining sealant backer rod.
 7. Fabricate metal **[drip edges]** **[and]** **[sealant stops]** for ribbed metal flashing from plain metal flashing of same metal as ribbed flashing and extending at least 3 inches (75 mm) into wall with hemmed inner edge to receive ribbed flashing and form a hooked seam. Form hem on upper surface of metal so that completed seam will shed water.
 8. Metal Drip Edges: Fabricate from stainless steel. Extend at least 3 inches (75 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.
 9. Metal Sealant Stops: Fabricate from stainless steel. Extend at least 3 inches (75 mm) into wall and out to exterior wall face. At exterior wall face, bend metal back on itself for 3/4 inch (19 mm) and down into joint 3/8 inch (10 mm) to form a stop for retaining sealant backer rod.
 10. Metal Expansion-Joint Strips: Fabricate from stainless steel copper to shapes indicated.
- B. Flexible Flashing: For flashing unexposed to the exterior, use the following unless otherwise indicated:

1. Copper-Laminated Flashing: 7-oz./sq. ft. (2-kg/sq. m) copper sheet bonded with asphalt between two layers of glass-fiber cloth. Use only where flashing is fully concealed in masonry.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Advanced Building Products Inc.
 - 2) Hohmann & Barnard, Inc.
 - 3) Phoenix Building Products.
 - 4) Sandell Manufacturing Co., Inc.
 - 5) Wire-Bond.
 - 6) York Manufacturing, Inc.
 - C. Application: Unless otherwise indicated, use the following:
 1. Where flashing is indicated to receive counterflashing, use metal flashing.
 2. Where flashing is indicated to be turned down at or beyond wall face, use metal flashing.
 3. Where flashing is partly exposed and is indicated to terminate at wall face, use metal flashing **[with a drip edge] [with a sealant stop] [or flexible flashing with a metal drip edge] [or elastomeric thermoplastic flashing with drip edge] [or flexible flashing with a metal sealant stop]**.
 4. Where flashing is fully concealed, use **[metal flashing] [or] [flexible flashing]**.
 - D. Solder and Sealants for Sheet Metal Flashings: As specified in Section 07 6200 "Sheet Metal Flashing and Trim."
 1. Solder for Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.
 2. Solder for Copper: ASTM B32, Grade Sn50.
 3. Elastomeric Sealant: ASTM C920, chemically curing urethane polysulfide silicone sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
 - E. Adhesives, Primers, and Seam Tapes for Flexible Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.
- 2.7 MISCELLANEOUS MASONRY ACCESSORIES
- A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene urethane or PVC.
 - B. Cementitious Dampproofing for Limestone: Cementitious formulation recommended by ILI and nonstaining to stone, compatible with joint sealants, and noncorrosive to veneer anchors and attachments.
 - C. Asphalt Dampproofing: Cut-back asphalt complying with ASTM D4479/D4479M, Type I asphalt emulsion complying with ASTM D1227, Type III or Type IV.
 - D. Weep/Vent Products: Use one of the following unless otherwise indicated:

1. Mesh Weep Holes/Vents: Free-draining mesh; made from polyethylene strands, full width of head joint and 2 inches (50 mm) high by thickness of stone masonry; in color selected from manufacturer's standard.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) CavClear/Archovations, Inc.
 - 2) Mortar Net Solutions.
 2. Aluminum Weep Holes/Vents: One-piece, L-shaped units made from painted sheet aluminum, designed to fit into head joint and consisting of vertical channel with louvers stamped in web and with top flap to keep mortar out of head joint.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Hohmann & Barnard, Inc.
 3. Vinyl Weep Holes/Vents: One-piece, offset, T-shaped units made from flexible, injection-molded PVC, designed to fit into head joint and consisting of louvered vertical leg, flexible wings to seal against ends of stone units, and top flap to keep mortar out of head joint; in color approved by Architect to match that of mortar.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Hohmann & Barnard, Inc.
 - 2) Williams Products, Inc.
 - 3) Wire-Bond.
- E. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Advanced Building Products Inc.
 - b. CavClear/Archovations, Inc.
 - c. Mortar Net Solutions.
 2. Provide one of the following configurations:
 - a. Strips, full depth of cavity and 10 inches (250 mm) wide, with dovetail-shaped notches 7 inches (175 mm) deep that prevent mesh from being clogged with mortar droppings.
 - b. Strips, not less than [3/4 inch (19 mm)] [1-1/2 inches (38 mm)] thick and 10 inches (250 mm) wide, with dimpled surface designed to catch mortar droppings and prevent weep holes from being clogged with mortar.
 - c. Sheets or strips full depth of cavity and installed to full height of cavity.
 - d. Sheets or strips not less than [3/4 inch (19 mm)] [1 inch (25 mm)] **<Insert dimension>** thick and installed to full height of cavity with additional strips 4 inches (100 mm) high at weep holes and thick enough to fill entire depth of cavity and prevent weep holes from being clogged with mortar.

2.8 MASONRY CLEANERS

- A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar and grout stains, efflorescence, and other new construction stains from stone masonry surfaces without discoloring or damaging masonry surfaces; expressly approved for intended use by cleaner manufacturer and stone producer.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Diedrich Technologies, Inc.; a Hohmann & Barnard company.
 - b. Dominion Restoration Products.
 - c. EaCo Chem, Inc.
 - d. Hydroclean; Hydrochemical Techniques, Inc.
 - e. PROSOCO, Inc.

2.9 FABRICATION

- A. General: Fabricate stone units in sizes and shapes required to comply with requirements indicated.
 - 1. For granite, comply with recommendations in NBGQA's "Specifications for Architectural Granite."
 - 2. For limestone, comply with recommendations in ILI's "Indiana Limestone Handbook."
- B. **[Cut] [Split] [Select]** stone to produce pieces of thickness, size, and shape indicated, including details on Drawings and pattern specified in "Setting Stone Masonry" Article.
 - 1. Shape stone specified to be laid in three-course, random range ashlar pattern with **[sawed] [split]** beds.
- C. Dress joints (bed and vertical) straight and at right angle to face unless otherwise indicated. Shape beds to fit supports.
- D. Cut and drill sinkages and holes in stone for anchors and supports.
- E. Carefully inspect stone at quarry or fabrication plant for compliance with requirements for appearance, material, and fabrication. Replace defective units before shipment.
 - 1. Clean sawed backs of stone to remove rust stains and iron particles.
- F. Thickness of Stone: Provide thickness indicated, but not less than the following:
 - 1. Thickness: 4 inches (100 mm) plus or minus [1/4 inch (6 mm)] [1/2 inch (13 mm)]. **[Thickness does not include projection of pitched faces.]**
- G. Finish exposed stone faces and edges to comply with requirements indicated for finish and to match approved samples **[and mockups]**.
 - 1. Finish: **[Split face] [Rock face (pitched face)] [Natural cleft] [Mixed split face and seam face] [Mixed split face, seam face, and rock face (pitched face)] [Smooth] [Sand rubbed] [As indicated].**
 - 2. Finish for Sills: **[Smooth] [Sand rubbed] [Split face with sand-rubbed washes] [Rock face (pitched face) with sand-rubbed washes] [Rock face (pitched face) with tooled (boasted) washes].**

3. Finish for Lintels: [Smooth] [Sand rubbed] [Split face] [Rock face (pitched face)].
4. Finish for Copings: [Smooth] [Sand rubbed] [Split face] [Rock face (pitched face), front and back; sand-rubbed top] [Rock face (pitched face), front and back; tooled (boasted) top].
 - a. Finish exposed ends of copings same as front and back faces.

2.10 MORTAR MIXES

- A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.
 1. Do not use calcium chloride.
 2. Use [portland cement-lime] [masonry cement] [or] [mortar cement] mortar unless otherwise indicated.
 3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.
 4. Mixing Pointing Mortar: Thoroughly mix cementitious and aggregate materials together before adding water. Then mix again, adding only enough water to produce a damp, unworkable mix that will retain its form when pressed into a ball. Maintain mortar in this dampened condition for one to two hours. Add remaining water in small portions until mortar reaches required consistency. Use mortar within 30 minutes of final mixing; do not retemper or use partially hardened material.
- B. Mortar for Stone Masonry: Comply with ASTM C270, Proportion Property Specification.
 1. Mortar for Setting Stone: Type S.
 2. Mortar for Pointing Stone: Type N.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive stone masonry, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of stone masonry.
- B. Examine substrate to verify that dovetail slots, inserts, reinforcement, veneer anchors, flashing, and other items installed in substrates and required for or extending into stone masonry are correctly installed.
- C. Examine wall framing, sheathing, and weather-resistant sheathing paper to verify that stud locations are suitable for spacing of veneer anchors and that installation will result in a weatherproof covering.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Accurately mark stud centerlines on face of weather-resistant sheathing paper before beginning stone installation.
- B. Coat concrete and unit masonry backup with asphalt dampproofing.

- C. Clean dirty or stained stone surfaces by removing soil, stains, and foreign materials before setting. Clean stone by thoroughly scrubbing with fiber brushes and then drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh materials or abrasives.

3.3 INSTALLATION OF STONE MASONRY

- A. Perform necessary field cutting and trimming as stone is set.
 - 1. Use power saws to cut stone that is fabricated with saw-cut surfaces. Cut lines straight and true, with edges eased slightly to prevent snipping.
 - 2. Use hammer and chisel to split stone that is fabricated with split surfaces. Make edges straight and true, matching similar surfaces that were shop or quarry fabricated.
 - 3. Pitch face at field-split edges as needed to match stones that are not field split.
- B. Sort stone before it is placed in wall to remove stone that does not comply with requirements relating to aesthetic effects, physical properties, or fabrication, or that is otherwise unsuitable for intended use.
- C. Arrange stones in range ashlar pattern with course heights as indicated, **[uniform] [random]** lengths, and uniform joint widths, with offset between vertical joints as indicated.
- D. Arrange stones in broken-range ashlar pattern with uniform course heights, random lengths, and uniform joint widths.
- E. Arrange stones in three-course, random-range ashlar pattern with random course heights, random lengths (interrupted coursed), and uniform joint widths.
- F. Arrange stones in **[coursed] [uncoursed]** rubble pattern with joint widths within tolerances indicated. **[Insert small stones into spaces between larger stones as needed to produce joints as uniform in width as practical.]**
- G. Arrange stones with color and size variations uniformly dispersed for an evenly blended appearance.
- H. Install supports, fasteners, and other attachments indicated or necessary to secure stone masonry in place.
- I. Set stone accurately in locations indicated with edges and faces aligned according to established relationships and indicated tolerances.
- J. Install steel lintels where indicated. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.
- K. Maintain uniform joint widths except for variations due to different stone sizes and where minor variations are required to maintain bond alignment if any. Lay walls with joints not less than **[1/4 inch (6 mm)] [3/8 inch (10 mm)]** at narrowest points or more than **[3/8 inch (10 mm)] [1/2 inch (13 mm)] [5/8 inch (16 mm)] [1 inch (25 mm)] [1-1/2 inches (38 mm)]** at widest points.
- L. Provide sealant joints of widths and at locations indicated.
 - 1. Keep sealant joints free of mortar and other rigid materials.

2. Sealant joints are specified in Section 07 9200 "Joint Sealants."
- M. Install metal expansion strips in sealant joints at locations indicated. Build flanges of expansion strips into masonry by embedding in mortar between stone masonry and backup wythe. Lap each joint 4 inches (100 mm) in direction of water flow. Seal joints below grade and at junctures with horizontal expansion joints if any.
- N. Install embedded flashing[**and weep holes**] at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated.
1. At stud-framed walls, extend flashing through stone masonry, up sheathing face at least [8 inches (200 mm)] [12 inches (300 mm)] [16 inches (400 mm)], and behind weather barrier.
 2. At multiwythe masonry walls, including cavity walls, extend flashing through stone masonry, turned up a minimum of [4 inches (100 mm)] [8 inches (200 mm)] [12 inches (300 mm)] [16 inches (400 mm)], and extend into or through inner wythe to comply with requirements in Section 04 2000 "Unit Masonry."
 3. At concrete backing, extend flashing through stone masonry, turned up a minimum of [4 inches (100 mm)] [6 inches (150 mm)] [8 inches (200 mm)] [12 inches (300 mm)], and insert in reglet.[**Reglets are specified in Section 07 6200 "Sheet Metal Flashing and Trim."**]
 4. At lintels and shelf angles, extend flashing full length of angles but not less than 6 inches (150 mm) into masonry at each end.
 5. At sills, extend flashing not less than 4 inches (100 mm) at ends.
 6. At ends of head and sill flashing, turn up not less than 2 inches (50 mm) to form end dams.
 7. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 07 9200 "Joint Sealants" for application indicated.
 8. Install metal drip edges sealant stops with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 07 9200 "Joint Sealants" for application indicated.
 9. Extend sheet metal flashing 1/2 inch (13 mm) beyond masonry face at exterior, and turn flashing down to form a drip.
 10. Install metal drip edges beneath flexible flashing at exterior wall face. Stop flexible flashing 1/2 inch (13 mm) back from exterior wall face and adhere flexible flashing to top of metal drip edge.
 11. Install metal flashing termination beneath flexible flashing at exterior wall face. Stop flexible flashing 1/2 inch (13 mm) back from exterior wall face and adhere flexible flashing to top of metal flashing termination.
 12. Cut flexible flashing flush with wall face after completing masonry wall construction.
- O. Place weep holes and vents in joints where moisture may accumulate, including at base of cavity walls, above shelf angles, and at flashing.
1. Use wicking material round plastic tubing rectangular plastic tubing mesh weep holes/vents aluminum weep holes/vents vinyl weep holes/vents to form weep holes.
 2. Use wicking material to form weep holes above flashing in stone sills. Turn wicking down at lip of sill to be as inconspicuous as possible.
 3. Space weep holes [16 inches (400 mm)] [24 inches (600 mm)] o.c.
 4. Space weep holes formed from wicking material 16 inches (400 mm) o.c.
 5. Trim wicking material used in weep holes flush with exterior wall face after mortar has set.
 6. Place pea gravel in cavities as soon as practical to a height of not less than 2 inches (50 mm) above top of flashing, to maintain drainage.

7. Place cavity drainage material in cavities to comply with configuration requirements for cavity drainage material in "Miscellaneous Masonry Accessories" Article.
- P. Install vents in head joints at top of each continuous cavity at spacing indicated. Use round plastic tubing rectangular plastic tubing mesh weep holes/vents aluminum weep holes/vents vinyl weep holes/vents to form vents.
 1. Close cavities off vertically and horizontally with blocking in manner indicated. Install through-wall flashing and weep holes above horizontal blocking.
- Q. Coat limestone with cementitious dampproofing as follows:
 1. Stone at Grade: Beds, joints, and back surfaces to at least 12 inches (300 mm) above finish-grade elevations.
 2. Stone Extending below Grade: Beds, joints, back surfaces, and face surfaces below grade.
 3. Allow cementitious dampproofing formulations to cure before setting dampproofed stone. Do not damage or remove dampproofing in the course of handling and setting stone.

3.4 CONSTRUCTION TOLERANCES

- A. Variation from Plumb: For vertical lines and surfaces, do not exceed 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (10 mm in 6 m), or 1/2 inch in 40 feet (13 mm in 12 m) or more. For external corners, expansion joints, control joints, and other conspicuous lines, do not exceed 1/4 inch in 20 feet (6 mm in 6 m) or 1/2 inch in 40 feet (13 mm in 12 m) or more.
- B. Variation from Level: For **bed joints and** lines of exposed lintels, sills, parapets, horizontal grooves, and other conspicuous lines, do not exceed 1/4 inch in 20 feet (6 mm in 6 m) or 1/2 inch in 40 feet (13 mm in 12 m) or more.
- C. Variation of Linear Building Line: For position shown in plan, do not exceed 1/2 inch in 20 feet (13 mm in 6 m) or 3/4 inch in 40 feet (19 mm in 12 m) or more.
- D. Measure variation from level, plumb, and position shown in plan as a variation of the average plane of each stone face from level, plumb, or dimensioned plane.
- E. Variation in Mortar-Joint Thickness: Do not vary from joint size range indicated.
- F. Variation in Plane between Adjacent Stones: Do not exceed one-half of tolerance specified for thickness of stone.

3.5 INSTALLATION OF ANCHORED STONE MASONRY

- A. Anchor stone masonry to concrete with corrugated-metal veneer anchors unless otherwise indicated. Secure anchors by inserting dovetailed ends into dovetail slots in concrete.
- B. Anchor stone masonry to unit masonry with veneer anchors unless otherwise indicated. Embed anchors in unit masonry mortar joints or grouted cells at a distance of at least one-half of unit masonry thickness.

- C. Anchor stone masonry to unit masonry with wire anchors unless otherwise indicated. Connect anchors to masonry joint reinforcement by inserting pintles into eyes of masonry joint reinforcement projecting from unit masonry.
- D. Anchor stone masonry to unit masonry with wire anchors unless otherwise indicated. Connect anchors to masonry joint reinforcement with vertical rods inserted through anchors and through eyes of masonry joint reinforcement projecting from unit masonry.
- E. Anchor stone masonry to unit masonry with **[adjustable, screw-attached]** **[seismic]** veneer anchors unless otherwise indicated. Fasten anchors to unit masonry with two screws.
- F. Anchor stone masonry to stud framing with **[adjustable, screw-attached]** **[seismic]** veneer anchors unless otherwise indicated. Fasten anchors through sheathing to framing with two screws.
- G. Anchor stone masonry to stud framing with screw-attached veneer anchors unless otherwise indicated.
- H. Anchor stone masonry to wood-stud framing with corrugated-metal veneer anchors unless otherwise indicated. Fasten anchors through sheathing to studs with corrosion-resistant roofing nails.
- I. Anchor stone masonry to wood-stud framing with wire anchors unless otherwise indicated. Fasten anchors through sheathing to wood studs with corrosion-resistant roofing nails.
- J. Anchor stone masonry to metal-stud framing with wire anchors unless otherwise indicated. Tie anchors to studs.
- K. Embed veneer anchors in mortar joints of stone masonry at least halfway, but not less than 1-1/2 inches (38 mm), through stone masonry and with at least a 5/8-inch (16-mm) cover on exterior face.
 - 1. Install continuous wire reinforcement in horizontal joints and attach to seismic veneer anchors as stone is set.
- L. Space anchors to provide not less than one anchor per 2 sq. ft. (0.2 sq. m) of wall area. Install additional anchors within 12 inches (300 mm) of openings, sealant joints, and perimeter at intervals not exceeding 12 inches (300 mm).
- M. Space anchors not more than 16 inches (400 mm) o.c. vertically and 24 inches (600 mm) o.c. horizontally. Install additional anchors within 12 inches (300 mm) of openings, sealant joints, and perimeter at intervals not exceeding 12 inches (300 mm).
- N. Space anchors not more than 18 inches (450 mm) o.c. vertically and 32 inches (800 mm) o.c. horizontally, with not less than one anchor per 2.67 sq. ft. (0.25 sq. m) of wall area. Install additional anchors within 12 inches (300 mm) of openings, sealant joints, and perimeter at intervals not exceeding 12 inches (300 mm).

- O. Anchor stone trim with stone trim anchors where indicated. Install anchors by fastening to substrate and inserting tabs and dowels into kerfs and holes in stone units. Provide compressible filler in ends of dowel holes and bottoms of kerfs to prevent end bearing of dowels and anchor tabs on stone. Fill remainder of anchor holes and kerfs with mortar.
- P. Set stone in full bed of mortar with full head joints unless otherwise indicated. Build anchors into mortar joints as stone is set.
- Q. Fill **[collar joint]** **[space between back of stone masonry and weather-resistant sheathing paper]** with mortar as stone is set.
- R. Provide **[1-inch (25-mm)]** **[2-inch (50-mm)]** cavity between stone masonry and backup construction unless otherwise indicated. Keep cavity free of mortar droppings and debris.
 - 1. Slope beds toward cavity to minimize mortar protrusions into cavity.
 - 2. Do not attempt to trowel or remove mortar fins protruding into cavity.
- S. Rake out joints for pointing with mortar to depth of not less than **[1/2 inch (13 mm)]** **[3/4 inch (19 mm)]** before setting mortar has hardened. Rake joints to uniform depths with square bottoms and clean sides.

3.6 POINTING

- A. Prepare stone-joint surfaces for pointing with mortar by removing dust and mortar particles. Where setting mortar was removed to depths greater than surrounding areas, apply pointing mortar in layers not more than 3/8 inch (10 mm) deep until a uniform depth is formed.
- B. Point stone joints by placing and compacting pointing mortar in layers of not more than 3/8 inch (10 mm) deep. Compact each layer thoroughly and allow to it become thumbprint hard before applying next layer.
- C. Tool joints, when pointing mortar is thumbprint hard, with a smooth jointing tool to produce the following joint profile:
 - 1. Joint Profile: **[Concave]** **[Smooth, flat face slightly below edges of stone]** **[Smooth, flat face recessed 1/4 inch (6 mm) below edges of stone (raked joint)]** **[Flush, with a 3/8-inch (10-mm) half-round raised bead in middle of joint]** **[As indicated]**.

3.7 ADJUSTING AND CLEANING

- A. Remove and replace stone masonry of the following description:
 - 1. Broken, chipped, stained, or otherwise damaged stone. Stone may be repaired if methods and results are approved by Architect.
 - 2. Defective joints.
 - 3. Stone masonry not matching approved samples and mockups.
 - 4. Stone masonry not complying with other requirements indicated.
- B. Replace in a manner that results in stone masonry matching approved samples and mockups, complying with other requirements, and showing no evidence of replacement.
- C. In-Progress Cleaning: Clean stone masonry as work progresses. Remove mortar fins and smears before tooling joints.

- D. Final Cleaning: After mortar is thoroughly set and cured, clean stone masonry as follows:
1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
 2. Test cleaning methods on mockup; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before cleaning stone masonry.
 3. Protect adjacent stone and nonmasonry surfaces from contact with cleaner by covering them with liquid strippable masking agent, polyethylene film, or waterproof masking tape.
 4. Wet wall surfaces with water before applying cleaner; remove cleaner promptly by rinsing thoroughly with clear water.
 5. Clean stone masonry by bucket and brush hand-cleaning method described in BIA Technical Note No. 20, Revised II, using job-mixed detergent solution.
 6. Clean stone masonry with proprietary acidic cleaner applied according to manufacturer's written instructions.
 7. Clean limestone masonry to comply with recommendations in ILI's "Indiana Limestone Handbook."

3.8 EXCESS MATERIALS AND WASTE

- A. Excess Stone: Stack excess stone where directed by Owner for Owner's use.
- B. Disposal as Fill Material: Dispose of clean masonry waste, including mortar and excess or soil-contaminated sand, by crushing and mixing with fill material as fill is placed.
1. Crush masonry waste to less than 4 inches (100 mm) in greatest dimension.
 2. Mix masonry waste with at least 2 parts of specified fill material for each part of masonry waste. Fill material is specified in Section 31 2000 "Earth Moving."
 3. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.
- C. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above, and other waste, and legally dispose of off Owner's property.

END OF SECTION

SECTION 05 5000 - METAL FABRICATIONS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Metal bollards.
- B. Products furnished, but not installed, under this Section include the following:
 - 1. Loose steel lintels.
 - 2. Steel weld plates and angles for casting into concrete for applications where they are not specified in other Sections.
 - 3. Anchor bolts, steel pipe sleeves, slotted-channel inserts, and wedge-type inserts indicated to be cast into concrete or built into unit masonry.
- C. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
 - 2. Section 04 2000 "Unit Masonry" for installing loose lintels, anchor bolts, and other items built into unit masonry.
 - 3. Section 05 1200 "Structural Steel Framing" for steel framing, supports, elevator machine beams, hoist beams, divider beams, door frames, and other steel items attached to the structural-steel framing.

1.2 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written instructions to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of metal fabrications that are anchored to or that receive other work. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Nonslip aggregates and nonslip-aggregate surface finishes.
 - 2. Fasteners.
 - 3. Metal bollards.
- B. Shop Drawings: Show fabrication and installation details. **[Include plans, elevations, sections, and details of metal fabrications and their connections. Show anchorage and accessory items.]** Provide Shop Drawings for the following:
 - 1. Elevator machine beams, hoist beams, and divider beams.
 - 2. Metal bollards.
 - 3. Loose steel lintels.

- C. Samples for Verification: For each type and finish of extruded **[nosing]** **[and]** **[tread]**.
- D. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
 - 1. Provide delegated-design submittals for the following:
 - a. Slotted channel framing.
 - b. Ladders.
 - c. Alternating tread devices.
 - d. Vehicular barrier cable.
- E. Sustainable Design Submittals:
 - 1. Environmental product declaration.
 - 2. Health Product Declaration (HPD): For each product.
 - 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following welding codes:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."
- B. Provide the following upon request:
 - 1. Mill Certificates: Signed by stainless steel manufacturers, certifying that products furnished comply with requirements.
 - 2. Welding certificates.
 - 3. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
 - 4. Research Reports: For post-installed anchors.
 - 5. Delegated design engineer qualifications.

1.5 FIELD CONDITIONS

- A. Field Measurements: Verify actual locations of walls, floor slabs, decks, and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design **[slotted channel framing]** **[ladders]** **[alternating tread devices]** **[and]** **[vehicular barrier cable systems]**.
 - 1. Material properties indicated in this Section shall be considered as minimum properties.
- B. Structural Performance of Aluminum Ladders: Ladders**[, including landings,]** are to withstand the effects of loads and stresses within limits and under conditions specified in ANSI/ASC A14.3.

- C. Structural Performance of Alternating Tread Devices: Alternating tread devices are to withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
1. Uniform Load: 100 lbf/sq. ft. (4.79 kN/sq. m).
 2. Concentrated Load: 300 lbf (1.33 kN) applied on an area of 4 sq. in. (2580 sq. mm).
 3. Uniform and concentrated loads need not be assumed to act concurrently.
 4. Alternating Tread Device Framing: Capable of withstanding stresses resulting from railing loads in addition to loads specified above.
 5. Comply with applicable railing loadings in Section 05 5213 "Pipe and Tube Railings."
- D. Vehicular Barrier Cable Systems: Design vehicular barrier cable systems to resist a single [6000-lbf (28.7-kN)] **<Insert value>** service load and [10,000-lbf (47.9-kN)] **<Insert load>** ultimate load applied horizontally in any direction to the cable system, with anchorages or attachments capable of transferring this load to the structure. Limit deflection to 18 inches (457 mm). Design is to assume loads are applied at a height of [18 inches (457 mm)] **<Insert height>** above the floor or ramp surface on an area not to exceed 1 sq. ft. (0.09 sq. m).
- E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 METALS

- A. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
- B. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- C. Steel Plates, Shapes, and Bars: ASTM A36/A36M.

2.3 FASTENERS

- A. General: Unless otherwise indicated, provide stainless steel fasteners for exterior use and zinc-plated fasteners with coating complying with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, at exterior walls. Select fasteners for type, grade, and class required.
1. Provide stainless steel fasteners for fastening .
 2. Provide bronze fasteners for fastening bronze.
- B. Steel Bolts and Nuts: Regular hexagon-head bolts, ASTM A307, Grade A (ISO 898-1, Property Class 4.6); with hex nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
- C. Anchor Bolts: ASTM F1554, Grade 36, of dimensions indicated; with nuts, ASTM A563 (ASTM A563M); and, where indicated, flat washers.
1. Hot-dip galvanize or provide mechanically deposited, zinc coating where item being fastened is indicated to be galvanized.

- D. Cast-in-Place Anchors in Concrete: Either threaded or wedge type unless otherwise indicated; galvanized ferrous castings, either ASTM A47/A47M malleable iron or ASTM A27/A27M cast steel. Provide bolts, washers, and shims as needed, all hot-dip galvanized per ASTM F2329/F2329M.

2.4 MISCELLANEOUS MATERIALS

- A. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - 1. Use primer that contains pigments that make it easily distinguishable from zinc-rich primer.
- B. Galvanizing Repair Paint: High-zinc-dust-content paint complying with SSPC-Paint 20 and compatible with paints specified to be used over it.

2.5 FABRICATION, GENERAL

- A. Shop Assembly: Preassemble items in the shop to greatest extent possible. Disassemble units only as necessary for shipping and handling limitations. Use connections that maintain structural value of joined pieces. Clearly mark units for reassembly and coordinated installation.
- B. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.
- C. Form bent-metal corners to smallest radius possible without causing grain separation or otherwise impairing work.
- D. Form exposed work with accurate angles and surfaces and straight edges.
- E. Weld corners and seams continuously to comply with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing[**and contour of welded surface matches that of adjacent surface**].
- F. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners or welds where possible. Where exposed fasteners are required, use Phillips flat-head (countersunk) fasteners unless otherwise indicated. Locate joints where least conspicuous.
- G. Fabricate seams and other connections that are exposed to weather in a manner to exclude water. Provide weep holes where water may accumulate.
- H. Cut, reinforce, drill, and tap metal fabrications as indicated to receive finish hardware, screws, and similar items.

- I. Provide for anchorage of type indicated; coordinate with supporting structure. Space anchoring devices to secure metal fabrications rigidly in place and to support indicated loads.
- J. Where units are indicated to be cast into concrete or built into masonry, equip with integrally welded steel strap anchors, 1/8 by 1-1/2 inches (3.2 by 38 mm), with a minimum 6-inch (150-mm) embedment and 2-inch (50-mm) hook, not less than 8 inches (200 mm) from ends and corners of units and 24 inches (600 mm) o.c., unless otherwise indicated.

2.6 METAL BOLLARDS

- A. Fabricate metal bollards from Schedule 40 steel pipe steel shapes, as indicated.
 - 1. Cap bollards with 1/4-inch- (6.4-mm-) thick, steel plate with domed top.
 - 2. Where bollards are indicated to receive controls for door operators, provide cutouts for controls and holes for wire.
 - 3. Where bollards are indicated to receive light fixtures, provide cutouts for fixtures and holes for wire.
- B. Fabricate sleeves for bollard anchorage from steel or stainless steel pipe with 1/4-inch- (6.4-mm-) thick, steel or stainless steel plate welded to bottom of sleeve. Make sleeves not less than 8 inches (200 mm) deep and 3/4 inch (19 mm) larger than OD of bollard.
- C. Prime steel bollards with primer specified in Section 09 9600 "High-Performance Coatings."
- D. Provide plastic protective sleeves for all pipe bollards. Unless otherwise shown, comply with the following:
 - 1. Low density polyethylene with UV inhibitors and:
 - a. Integral domed top.
 - b. Sleeve wall thickness: Minimum 1/4 inches (6 mm).
 - c. Circular in cross-section.
 - 2. Length of sleeve, not including domed top: Not more than 2 inches (50 mm) longer than height of bollard above grade or floor.
 - 3. Include manufacturer's recommended mounting tape or other materials.
 - 4. Manufacturer: Ideal Shield or approved comparable product.

2.7 LOOSE STEEL LINTELS

- A. Fabricate loose steel lintels from steel angles and shapes of size indicated for openings and recesses in masonry walls and partitions at locations indicated. Fabricate in single lengths for each opening unless otherwise indicated. Weld adjoining members together to form a single unit where indicated.
- B. Size loose lintels to provide bearing length at each side of openings equal to one-twelfth of clear span, but not less than 8 inches (200 mm) unless otherwise indicated.
- C. Galvanize[**and prime**] loose steel lintels located in exterior walls.
- D. Prime loose steel lintels located in exterior walls with primer specified in Section 09 9600 "High-Performance Coatings."

2.8 STEEL WELD PLATES AND ANGLES

- A. Provide steel weld plates and angles not specified in other Sections, for items supported from concrete construction as needed to complete the Work. Provide each unit with no fewer than two integrally welded steel strap anchors for embedding in concrete.

2.9 GENERAL FINISH REQUIREMENTS

- A. Finish metal fabrications after assembly.
- B. Finish exposed surfaces to remove tool and die marks and stretch lines, and to blend into surrounding surface.

2.10 STEEL AND IRON FINISHES

- A. Galvanizing: Hot-dip galvanize items as indicated to comply with ASTM A153/A153M for steel and iron hardware and with ASTM A123/A123M for other steel and iron products.
 - 1. Hot-dip galvanize steel fabrications [**exposed to weather**][**where indicated**].
 - 2. Do not quench or apply post galvanizing treatments that might interfere with paint adhesion.
- B. Preparation for Shop Priming Galvanized Items: After galvanizing, thoroughly clean galvanized surfaces of grease, dirt, oil, flux, and other foreign matter, and treat with metallic phosphate process.
- C. Shop prime iron and steel items[**not indicated to be galvanized**] unless they are to be embedded in concrete, sprayed-on fireproofing, or masonry, or unless otherwise indicated.
 - 1. Shop prime with [**universal shop primer**] [**primers specified in Section 09 9113 "Exterior Painting"**] [**primers specified in Section 09 9123 "Interior Painting"**] unless [**zinc-rich primer is**] [**primers specified in Section 09 9600 "High-Performance Coatings"** are] indicated.
- D. Shop Priming: Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting.
 - 1. Stripe paint corners, crevices, bolts, welds, and sharp edges.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Cutting, Fitting, and Placement: Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, alignment, and elevation; with edges and surfaces level, plumb, true, and free of rack; and measured from established lines and levels.
- B. Fit exposed connections accurately together to form hairline joints. Weld connections that are not to be left as exposed joints but cannot be shop welded because of shipping size limitations. Do not weld, cut, or abrade surfaces of exterior units that have been hot-dip galvanized after fabrication and are for bolted or screwed field connections.

- C. Field Welding: Comply with the following requirements:
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. At exposed connections, finish exposed welds and surfaces smooth and blended so no roughness shows after finishing and contour of welded surface matches that of adjacent surface.
- D. Fastening to In-Place Construction: Provide anchorage devices and fasteners where metal fabrications are required to be fastened to in-place construction. Provide threaded fasteners for use with concrete and masonry inserts, toggle bolts, through bolts, lag screws, wood screws, and other connectors.
- E. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
- F. Corrosion Protection: Coat concealed surfaces of aluminum that come into contact with grout, concrete, masonry, wood, or dissimilar metals with the following:
1. Cast Aluminum: Heavy coat of bituminous paint.
 2. Extruded Aluminum: Two coats of clear lacquer.

3.2 INSTALLATION OF METAL BOLLARDS

- A. Fill metal-capped bollards solidly with concrete and allow concrete to cure seven days before installing.
1. Do not fill removable bollards with concrete.
- B. Anchor bollards to existing construction with **[expansion anchors] [anchor bolts] [through bolts]**. Provide four 3/4-inch (19-mm) bolts at each bollard unless otherwise indicated.
1. Embed anchor bolts at least 4 inches (100 mm) in concrete.
- C. Anchor bollards in concrete **[with pipe sleeves preset and anchored into concrete] [in formed or core-drilled holes not less than 42 inches (1050 mm) deep and 3/4 inch (19 mm) larger than OD of bollard]**. Fill annular space around bollard solidly with shrinkage-resistant grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch (3 mm) toward bollard.
- D. Anchor bollards in place with concrete footings. Center and align bollards in holes 3 inches (75 mm) above bottom of excavation. Place concrete and vibrate or tamp for consolidation. Support and brace bollards in position until concrete has cured.
- E. Anchor internal sleeves for removable bollards in **[concrete by inserting in pipe sleeves preset into concrete] [formed or core-drilled holes not less than 42 inches (1050 mm) deep and 3/4 inch (19 mm) larger than OD of sleeve]**. Fill annular space around internal sleeves solidly with shrinkage-resistant grout; mixed and placed to comply with grout manufacturer's written instructions. Slope grout up approximately 1/8 inch (3 mm) toward internal sleeve.

- F. Place removable bollards over internal sleeves and secure with 3/4-inch (19-mm) machine bolts and nuts. After tightening nuts, drill holes in bolts for inserting padlocks. Owner furnishes padlocks.
- G. Fill bollards solidly with concrete, mounding top surface to shed water.
 - 1. Do not fill removable bollards with concrete.

3.3 REPAIRS

- A. Touchup Painting:
 - 1. Immediately after erection, clean field welds, bolted connections, and abraded areas. Paint uncoated and abraded areas with same material as used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
 - 2. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in [Section 09 9113 "Exterior Painting."] [Section 09 9123 "Interior Painting."]
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.

END OF SECTION

SECTION 05 5213 - PIPE AND TUBE RAILINGS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Steel railings.
 - 2. Aluminum railings.
 - 3. Stainless steel railings.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
 - 2. Section 05 5113 "Metal Pan Stairs" for steel tube railings associated with metal pan stairs.
 - 3. Section 05 7300 "Decorative Metal Railings" for ornamental railings fabricated from pipes and tubes and guard-infill metals.
 - 4. Section 09 6900 "Access Flooring" for railings included with access flooring.

1.2 COORDINATION

- A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.
- B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.3 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 01 3300 "Submittal Procedures".
- B. Product Data:
 - 1. Manufacturer's product lines of mechanically connected railings.
 - 2. Expanded metal infill panels.
 - 3. Perforated metal infill panels.
 - 4. Woven-wire mesh infill panels.
 - 5. Fasteners.
 - 6. Post-installed anchors.
 - 7. Handrail brackets.
 - 8. Shop primer.
 - 9. Intermediate coats and topcoats.
 - 10. Bituminous paint.
 - 11. Nonshrink, nonmetallic grout.
 - 12. Anchoring cement.

- 13. Metal finishes.
- 14. Paint products.

C. Sustainable Design Submittals:

D. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

E. Samples for Initial Selection: For products involving selection of color, texture, or design, including mechanical finishes.

F. Samples for Verification: For each type of exposed finish required.

- 1. Sections of each distinctly different linear railing member, including handrails, top rails, posts, and balusters, including finish.
- 2. Fittings and brackets.
- 3. Assembled Sample of railing system, made from full-size components, including top rail, post, handrail, and infill. Sample need not be full height.
 - a. Show method of connecting and finishing members at intersections.

G. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.

- 1. Provide delegated-design submittals for railings.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

- 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
- 3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

B. Provide the following upon request:

- 1. Qualification Data: For delegated design professional engineer.
- 2. Welding certificates.
- 3. Mill Certificates: Signed by manufacturers of stainless steel products, certifying that products furnished comply with requirements.
- 4. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.
- 5. Product Test Reports: For tests on railings performed by a qualified testing agency, in accordance with ASTM E894 and ASTM E935.
- 6. Research Reports: For post-installed anchors, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design railings, including attachment to building construction.
 - 1. Material properties indicated in this Section shall be considered as minimum properties.
- B. Structural Performance: Railings, including attachment to building construction, withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1. Handrails and Top Rails of Guards:
 - a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
 - b. Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c. Uniform and concentrated loads need not be assumed to act concurrently.
 - 2. Infill of Guards:
 - a. Concentrated load of 50 lbf (0.22 kN) applied horizontally on an area of 1 sq. ft. (0.093 sq. m).
 - b. Infill load and other loads need not be assumed to act concurrently.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 METALS, GENERAL

- A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.
- B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.
 - 1. Provide type of bracket with flange tapped for concealed anchorage to threaded hanger bolt and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface.

2.3 STEEL RAILINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Hollaender Mfg. Co.
 - 2. Kee Safety, Inc.
 - 3. R & B Wagner, Inc.
 - 4. Trex Commercial Products, Inc.
 - 5. TrueNorth Steel.
 - 6. Tuttle, a Dant Clayton Division.
 - 7. VIVA Railings, LLC.
- B. Source Limitations: Obtain each type of railing from single source from single manufacturer.

- C. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
 - D. Tubing: ASTM A500/A500M (cold formed) ASTM A513/A513M, Type 5.
 - E. Pipe: ASTM A53/A53M, Type F or Type S, Grade A, Standard Weight (Schedule 40), unless another grade and weight are required by structural loads.
 - 1. Provide galvanized finish for exterior installations and where indicated.
 - F. Plates, Shapes, and Bars: ASTM A36/A36M.
 - G. Cast Iron Fittings: Either gray iron, ASTM A48/A48M, or malleable iron, ASTM A47/A47M, unless otherwise indicated.
 - H. Expanded Metal Infill Panels: ASTM F1267, Type I (expanded) Type II (expanded and flattened), Class 1 (uncoated).
 - 1. Style Designation: 3/4 number 13 1-1/2 number 10 Insert designation.
 - I. Perforated-Metal Infill Panels:
 - 1. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, or hot-rolled steel sheet, ASTM A1011/A1011M, commercial steel, Type B, 0.060 inch (1.52 mm) Insert dimension thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows Insert description.
 - a. Basis-of-Design Product: Provide product with perforations matching product indicated on Drawings.
 - 2. Galvanized-Steel Sheet: ASTM A653/A653M, G90 (Z275) coating, commercial steel Type B, 0.064 inch (1.63 mm) Insert dimension thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows with 1/8-by-1-inch (3.2-by-25.4-mm) round end slotted holes in staggered rows Insert description.
 - a. Basis-of-Design Product: Provide product with perforations matching product indicated on Drawings.
 - J. Woven-Wire Mesh Infill Panels: Intermediate-crimp, diamond square pattern, 2-inch (50-mm) woven-wire mesh, made from 0.134-inch- (3.42-mm-) diameter steel wire complying with ASTM A510 (ASTM A510M).
 - 1. Basis-of-Design Product: Provide product with crimp pattern matching product indicated on Drawings.
- 2.4 ALUMINUM RAILINGS
- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. ATR Technologies, Inc.
 - 2. AZEK Building Products, Inc.
 - 3. Blum, Julius & Co., Inc.
 - 4. CraneVeyor Corp.
 - 5. Fixfast USA.
 - 6. Hollaender Mfg. Co.
 - 7. Kane Innovations, Inc.
 - 8. Kee Industrial Products, Inc.
 - 9. Moultrie Manufacturing Corporation.

10. R & B Wagner, Inc.
11. Superior Aluminum Products, Inc.
12. Thompson Fabricating, LLC.
13. Trex Commercial Products, Inc.
14. Tri Tech, Inc.
15. Tubular Specialties Manufacturing, Inc.
16. Tuttle, a Dant Clayton Division.

- B. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- C. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.
- D. Extruded Bars and Tubing: ASTM B221 (ASTM B221M), Alloy 6063-T5/T52.
- E. Extruded Structural Pipe and Round Tubing: ASTM B429/B429M, Alloy 6063-T6.
1. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.
- F. Drawn Seamless Tubing: ASTM B210/B210M, Alloy 6063-T832.
- G. Plate and Sheet: ASTM B209 (ASTM B209M), Alloy 6061-T6.
- H. Die and Hand Forgings: ASTM B247 (ASTM B247M), Alloy 6061-T6.
- I. Castings: ASTM B26/B26M, Alloy A356.0-T6.
- J. Perforated Metal Infill Panels: Aluminum sheet, ASTM B209 (ASTM B209M), Alloy 6061-T6, 0.063 inch (1.60 mm) Insert dimension thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows Insert description.
1. Basis-of-Design Product: Provide product with perforations matching product indicated on Drawings.
- K. Woven-Wire Mesh Infill Panels: Intermediate-crimp, diamond square pattern, 2-inch (50-mm) woven-wire mesh, made from 0.162-inch- (4.1-mm-) diameter aluminum wire complying with ASTM B211/B211M, Alloy 6061-T94.
1. Basis-of-Design Product: Provide product with crimp pattern matching product indicated on Drawings.

2.5 STAINLESS STEEL RAILINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Blum, Julius & Co., Inc.
 2. CraneVeyor Corp.
 3. Kane Innovations, Inc.
 4. R & B Wagner, Inc.
 5. Stainless Fabricators, Inc.
 6. Trex Commercial Products, Inc.
 7. Tri Tech, Inc.
 8. Tubular Specialties Manufacturing, Inc.

9. Tuttle, a Dant Clayton Division.
 10. VIVA Railings, LLC.
- B. Source Limitations: Obtain each type of railing from single source from single manufacturer.
- C. Tubing: ASTM A554, Grade MT 304 Grade MT 316L.
- D. Pipe: ASTM A312/A312M, Grade TP 304 Grade TP 316L.
- E. Castings: ASTM A743/A743M, Grade CF 8 or CF 20 Grade CF 8M or CF 3M.
- F. Plate and Sheet: ASTM A240/A240M or ASTM A666, Type 304 Type 316L.
- G. Expanded Metal Infill Panels: ASTM F1267, Type I (expanded) Type II (expanded and flattened), Class 3 (corrosion-resistant steel), made from stainless steel sheet, ASTM A240/A240M or ASTM A666, Type 304 Type 316.
1. Style Designation: 3/4 number 13 1-1/2 number 10 Insert designation.
- H. Perforated Metal Infill Panels: Stainless steel sheet, ASTM A240/A240M or ASTM A666, Type 304 Type 316L, 0.062 inch (1.59 mm) Insert dimension thick, with 1/4-inch (6.4-mm) holes 3/8 inch (9.5 mm) o.c. in staggered rows Insert description.
1. Basis-of-Design Product: Provide product with perforations matching product indicated on Drawings.
- I. Woven-Wire Mesh Infill Panels: Intermediate-crimp, diamond square pattern, 2-inch (50-mm) woven-wire mesh, made from 0.141-inch- (3.57-mm-) diameter stainless steel wire complying with ASTM A580/A580M, Type 304 Type 316.
1. Basis-of-Design Product: Provide product with crimp pattern matching product indicated on Drawings.
- 2.6 FASTENERS
- A. Fastener Materials:
1. Ungalvanized-Steel Railing Components: Plated steel fasteners complying with ASTM F1941/F1941M, Class Fe/Zn 5 for zinc coating.
 2. Hot-Dip Galvanized Railing Components: Type 304 stainless steel or hot-dip zinc-coated steel fasteners complying with ASTM A153/A153M or ASTM F2329/F2329M for zinc coating.
 3. Aluminum Railing Components: Type 304 Type 316 stainless steel fasteners.
 4. Stainless Steel Railing Components: Type 304 Type 316 stainless steel fasteners.
 5. Finish exposed fasteners to match appearance, including color and texture, of railings.
- B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction and capable of withstanding design loads.
- C. Fasteners for Interconnecting Railing Components:
1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless otherwise indicated.
 2. Provide Phillips tamper-resistant square or hex socket flat-head machine screws for exposed fasteners unless otherwise indicated.

- D. Post-Installed Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or ICC-ES AC308.
 - 1. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941/F1941M, Class Fe/Zn 5, unless otherwise indicated.
 - 2. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) Group 2 (A4) stainless steel bolts, ASTM F593, and nuts, ASTM F594.

2.7 MISCELLANEOUS MATERIALS

- A. Handrail Brackets: Cast iron Cast aluminum, Cast stainless steel, Cast nickel-silver, center of handrail 2-1/2 inches (63.5 mm) 3-1/8 inches (79.4 mm) Insert dimension from face of railing wall.
- B. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.
 - 1. For aluminum stainless steel railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.
- C. Etching Cleaner for Galvanized Metal: Complying with MPI#25.
- D. Galvanizing Repair Paint: High-zinc-dust-content paint, complying with SSPC-Paint 20 and compatible with paints specified to be used over it.
- E. Shop Primers: Provide primers that comply with Section 09 9113 "Exterior Painting." Section 09 9123 "Interior Painting." Section 09 9600 "High-Performance Coatings."
- F. Universal Shop Primer: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with MPI#79 and compatible with topcoat.
 - 1. Use primer containing pigments that make it easily distinguishable from zinc-rich primer.
- G. Epoxy Zinc-Rich Primer: Complying with MPI#20 and compatible with topcoat.
- H. Shop Primer for Galvanized Steel: Primer formulated for exterior use over zinc-coated metal and compatible with finish paint systems indicated.
- I. Intermediate Coats and Topcoats: Provide products that comply with Section 09 9113 "Exterior Painting." Section 09 9123 "Interior Painting." Section 09 9600 "High-Performance Coatings."
- J. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
- K. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.
- L. Bituminous Paint: Cold-applied asphalt emulsion, complying with ASTM D1187/D1187M.
- M. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout, complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

- N. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound.
1. Water-Resistant Product: At exterior locations where indicated on Drawings, provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended by manufacturer for exterior use.

2.8 FABRICATION

- A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.
- B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.
1. Clearly mark units for reassembly and coordinated installation.
 2. Use connections that maintain structural value of joined pieces.
- C. Cut, drill, and punch metals cleanly and accurately.
1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
 2. Remove sharp or rough areas on exposed surfaces.
- D. Form work true to line and level with accurate angles and surfaces.
- E. Fabricate connections that are exposed to weather in a manner that excludes water.
1. Provide weep holes where water may accumulate.
 2. Locate weep holes in inconspicuous locations.
- F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.
- G. Connections: Fabricate railings with welded connections unless otherwise indicated.
- H. Gates: Form gates from steel tube of same size and shape as top rails, with infill to match guards. Provide with spring hinges for fastening to wall and overlapping stop with rubber bumper to prevent gate from opening in direction opposite egress.
- I. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.
1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove flux immediately.
 4. At exposed connections, finish exposed welds to comply with NOMMA's "Voluntary Joint Finish Standards" for Finish #1 welds; ornamental quality with no evidence of a welded joint.
- J. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.

- K. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.
1. Fabricate splice joints for field connection, using an epoxy structural adhesive, if this is manufacturer's standard splicing method.
- L. Form changes in direction as follows:
1. As detailed.
 2. By bending or by inserting prefabricated elbow fittings.
 3. By flush bends or by inserting prefabricated flush-elbow fittings.
 4. By radius bends of radius indicated or by inserting prefabricated elbow fittings of radius indicated.
 5. By bending to smallest radius that will not result in distortion of railing member.
- M. Bend members in jigs to produce uniform curvature for each configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.
- N. Close exposed ends of hollow railing members with prefabricated cap and end fittings of same metal and finish as railings.
- O. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch (6 mm) or less.
- P. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.
1. At brackets and fittings fastened to plaster or gypsum board partitions, provide crush-resistant fillers or other means to transfer loads through wall finishes to structural supports and prevent bracket or fitting rotation and crushing of substrate.
- Q. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work.
1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
 2. Coordinate anchorage devices with supporting structure.
- R. For railing posts set in concrete, provide stainless steel sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.
- S. For removable railing posts, fabricate slip-fit sockets from stainless steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height.
1. Provide socket covers designed and fabricated to resist being dislodged.
 2. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.
- T. Expanded-Metal Infill Panels: Fabricate infill panels from expanded-metal sheet of same metal as railings.
1. Edge panels with U-shaped channels made from metal sheet, of same metal as expanded metal and not less than 0.043 inch (1.1 mm) thick.
 2. Orient expanded metal with long dimension of diamonds perpendicular to top rail.

- U. Perforated-Metal Infill Panels: Fabricate infill panels from perforated metal made from same metal as railings in which they are installed.
 - 1. Edge panels with U-shaped channels made from metal sheet, of same metal as perforated metal and not less than 0.043 inch (1.1 mm) thick.
 - 2. Orient perforated metal with pattern as indicated on Drawings.
- V. Woven-Wire Mesh Infill Panels: Fabricate infill panels from woven-wire mesh crimped into 1-by-1/2-by-1/8-inch (25-by-13-by-3-mm) metal channel frames.
 - 1. Fabricate wire mesh and frames from same metal as railings in which they are installed.
 - 2. Orient wire mesh with as indicated on Drawings.
- W. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.9 STEEL AND IRON FINISHES

- A. Galvanized Railings:
 - 1. Hot-dip galvanize exterior steel railings, including hardware, after fabrication.
 - 2. Comply with ASTM A123/A123M for hot-dip galvanized railings.
 - 3. Comply with ASTM A153/A153M for hot-dip galvanized hardware.
 - 4. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
 - 5. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
- B. For galvanized railings, provide hot-dip galvanized fittings, brackets, fasteners, sleeves, and other ferrous components.
- C. Preparing Galvanized Railings for Shop Priming: After galvanizing, thoroughly clean railings of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner and as follows.
 - 1. Comply with SSPC-SP 16.
- D. For nongalvanized-steel railings, provide nongalvanized ferrous-metal fittings, brackets, fasteners, and sleeves; however, hot-dip galvanize anchors to be embedded in exterior concrete or masonry.
- E. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 6/NACE No. 3. SSPC-SP 3. requirements indicated below:
 - 1. Exterior Railings: SSPC-SP 6/NACE No. 3.
 - 2. Railings Indicated To Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3.
 - 3. Railings Indicated To Receive Primers Specified in Section 09 9600 "High-Performance Coatings": SSPC-SP 6/NACE No. 3.
 - 4. Other Railings: SSPC-SP 3.
- F. Primer Application: Apply shop primer to prepared surfaces of railings unless otherwise indicated. Comply with requirements in SSPC-PA 1 for shop painting. Primer need not be applied to surfaces to be embedded in concrete or masonry.
 - 1. Shop prime uncoated railings with primers specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting" unless primers specified in Section 09 9600 "High-Performance Coatings" are indicated.

2. Do not apply primer to galvanized surfaces.
- G. Shop-Painted Finish: Comply with Section 09 9113 "Exterior Painting." Section 09 9600 "High-Performance Coatings."
1. Color: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range.
- H. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1 for shop painting. Apply at spreading rates recommended by coating manufacturer.
1. Color: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range.
- 2.10 ALUMINUM FINISHES
- A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Mill Finish: AA-M12, nonspecular as fabricated.
- C. Clear Anodic Finish: AAMA 611, AA-M12C22A41 AA-M12C22A31.
- D. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44 AA-M12C22A32/A34.
1. Color: As selected by Architect from full range of industry colors and color densities.
- E. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
1. Color and Gloss: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range Insert color and gloss.
- F. High-Performance Organic Finish, Two-Coat Polyvinylidene Fluoride (PVDF): Fluoropolymer finish complying with AAMA 2604 AAMA 2605 and containing not less than 50 70 percent polyvinylidene fluoride (PVDF) resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions .
1. Color and Gloss: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range Insert color and gloss.
- 2.11 STAINLESS STEEL FINISHES
- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
1. Run grain with long dimension of each piece.
 2. When polishing is completed, passivate and rinse surfaces.
 3. Remove embedded foreign matter and leave surfaces chemically clean.

- C. Stainless Steel Pipe and Tubing Finishes:
 - 1. 180-Grit Polished Finish: Uniform, directionally textured finish.
- D. Stainless Steel Sheet and Plate Finishes:
 - 1. Directional Satin Finish: ASTM A480/A480, No. 4.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine plaster and gypsum board assemblies, where reinforced to receive anchors, to verify that locations of concealed reinforcements are clearly marked for Installer. Locate reinforcements and mark locations if not already done.

3.2 INSTALLATION, GENERAL

- A. Perform cutting, drilling, and fitting required for installing railings.
 - 1. Fit exposed connections together to form tight, hairline joints.
 - 2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
 - 3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
 - 4. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
 - 5. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
 - 6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).
- B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.
 - 1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.
- C. Adjust railings before anchoring to ensure matching alignment at abutting joints.
- D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.3 RAILING CONNECTIONS

- A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Use wood blocks and padding to prevent damage to railing members and fittings. Seal recessed holes of exposed locking screws, using plastic cement filler colored to match finish of railings.
- B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.

- C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches (50 mm) beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches (150 mm) of post.

3.4 ANCHORING POSTS

- A. Use stainless steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
- B. Form or core-drill holes not less than 5 inches (125 mm) deep and 3/4 inch (20 mm) larger than OD of post for installing posts in concrete. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions.
- C. Cover anchorage joint with flange of same metal as post, welded to post after placing anchoring material.
- D. Leave anchorage joint exposed with 1/8-inch (3-mm) buildup, sloped away from post.
- E. Anchor posts to metal surfaces with flanges, angle type, or floor type, as required by conditions, connected to posts and to metal supporting members as follows:
 - 1. For steel railings, weld flanges to post and bolt to metal supporting surfaces.
 - 2. For aluminum railings, attach posts as indicated, using fittings designed and engineered for this purpose.
 - 3. For stainless steel railings, weld flanges to post and bolt to supporting surfaces.
- F. Install removable railing sections, where indicated, in slip-fit stainless steel sockets cast in concrete.

3.5 ATTACHING RAILINGS

- A. Anchor railing ends to concrete and masonry with sleeves concealed within railing ends and anchored to wall construction with anchors and bolts.
- B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends or connected to railing ends, using nonwelded connections.
- C. Attach handrails to walls with wall brackets, except where end flanges are used. Provide brackets with 1-1/2-inch (38-mm) clearance from inside face of handrail and finished wall surface.
 - 1. Use type of bracket with flange tapped for concealed anchorage to threaded hanger bolt.
 - 2. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.
- D. Secure wall brackets and railing end flanges to building construction as follows:
 - 1. For concrete and solid masonry anchorage, use drilled-in expansion shields and hanger or lag bolts.

2. For hollow masonry anchorage, use toggle bolts.
3. For wood stud partitions, use hanger or lag bolts set into studs or wood backing between studs. Coordinate with carpentry work to locate backing members.
4. For steel-framed partitions, use hanger or lag bolts set into fire-retardant-treated wood backing between studs. Coordinate with stud installation to locate backing members.
5. For steel-framed partitions, fasten brackets directly to steel framing or concealed steel reinforcements, using self-tapping screws of size and type required to support structural loads.
6. For steel-framed partitions, use toggle bolts installed through flanges of steel framing or through concealed steel reinforcements.

E. Install railing gates level, plumb, and secure for full opening without interference.

1. Attach hardware using tamper-resistant or concealed means.
2. Adjust hardware for smooth operation.

3.6 REPAIR

A. Touchup Painting:

1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material used for shop painting to comply with SSPC-PA 1 for touching up shop-painted surfaces.
 - a. Apply by brush or spray to provide a minimum 2.0-mil (0.05-mm) dry film thickness.
2. Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint are specified in Section 09 9113 "Exterior Painting."

3.7 CLEANING

- A. Clean aluminum and stainless steel by washing thoroughly with clean water and soap and rinsing with clean water.
- B. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and repair galvanizing to comply with ASTM A780/A780M.

3.8 PROTECTION

- A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.
- B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION

SECTION 05 7800 – DECORATIVE METAL BATTENS

PART 1 - GENERAL

1.1 ADMINISTRATIVE REQUIREMENTS

- A. Pre-Installation Conference:
 - 1. Attendance: Architect, Contractor, installer, and related trades.
 - 2. Review: Project conditions, manufacturer requirements, delivery and storage, staging and sequencing, and protection of completed work.

1.2 SUBMITTALS

- A. Action Submittals:
 - 1. Shop Drawings: Illustrate products, installation, and relationship to adjacent construction.
 - 2. Product Data: Manufacturer's descriptive data and product attributes.
 - 3. Samples: [Selection samples.] [Verification samples.]
- B. Informational Submittals:
 - 1. Certificate of Compliance: Certification that installed products meet specified design and performance requirements.
- C. Closeout Submittals:
 - 1. Maintenance Data.
 - 2. Extra materials: [____] linear feet of profile and finish installed.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Minimum [2] [____] years' experience in work of this Section or installer supervised by manufacturer's representative.
- B. Mockups: Each batten profile, minimum [8] [____] feet long. Approved mockups [may] [may not] remain as part of the Work.
- C. Fire Hazard Classification, tested to ASTM E84.
 - 1. Flame spread: 0.
 - 2. Smoke developed: Maximum 60.

1.4 WARRANTY

- A. Manufacturer's 15 year warranty against defects in materials.
- B. Installer's [5] [____] year warranty against defects in workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Contract Documents are based on products by Parallel Architectural Products.
www.parallelap.com

- B. Substitutions: Refer to Division 01.

2.2 COMPONENTS

- A. Decorative Metal Battens:

1. Description: Extruded aluminum profiles with powder coating on exposed surfaces.
2. Aluminum extrusions: ASTM B221, alloy and temper best suited to application.
3. Powder coating: TGIC-free polyester meeting performance requirements of AAMA 2604.
4. Profile: [Nominally [] inches wide x [] inches deep.] [Refer to Drawings.]
5. Color: [].] [To be selected from manufacturer's full range OF [Woodgrain – Standard] [Woodgrain - Non-Standard] [Solid – Standard] [Solid – Non-Standard] colors.]

2.3 ACCESSORIES

- A. Clips and Other Attachments: Extruded aluminum, size and profile to suit project conditions.
- B. Fasteners: [AISI 1016, zinc-plated steel.] [Fluoropolymer coated steel.] [Manufacturers' recommended fastener.]

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install in accordance with manufacturer's instructions and approved Shop Drawings.

END OF SECTION

SECTION 06 1000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wood products.
 - 2. Fire-retardant-treated lumber.
 - 3. Miscellaneous lumber.
 - 4. Plywood backing panels.
- B. Related Requirements:
 - 1. Section 06 1600 "Sheathing" for sheathing, subflooring, and underlayment.

1.2 DEFINITIONS

- A. Boards or Strips: Lumber of less than 2 inches nominal (38 mm actual) size in least dimension.
- B. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) size or greater but less than 5 inches nominal (114 mm actual) size in least dimension.
- C. Exposed Framing: Framing not concealed by other construction.
- D. Lumber grading agencies, and abbreviations used to reference them, include the following:
 - 1. NeLMA: Northeastern Lumber Manufacturers Association.
 - 2. NLGA: National Lumber Grades Authority.
 - 3. SPIB: The Southern Pine Inspection Bureau.
 - 4. WCLIB: West Coast Lumber Inspection Bureau.
 - 5. WWPA: Western Wood Products Association.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Include physical properties of treated materials based on testing by a qualified independent testing agency.
 - 2. For fire-retardant treatments, include physical properties of treated lumber both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5664.
- B. Sustainable Design Submittals:
 - 1. Chain-of-Custody Qualification Data: For manufacturer and vendor.

1.4 QUALITY ASSURANCE

- A. Certified Wood: Provide an invoice including vendor's chain-of-custody number, product cost, and entity being invoiced.

- B. Vendor Qualifications: A vendor that is certified for chain of custody by an FSC-accredited certification body.
- C. Provide the following upon request:
 - 1. Material Certificates:
 - a. For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
 - b. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Stack wood products flat with spacers beneath and between each bundle to provide air circulation. Protect wood products from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS

- A. Regional Materials: Wood products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- B. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.
 - 1. Factory mark each piece of lumber with grade stamp of grading agency.
 - 2. For exposed lumber indicated to receive a stained or natural finish, [**mark grade stamp on end or back of each piece**] [or] [**omit grade stamp and provide certificates of grade compliance issued by grading agency**].
 - 3. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
 - 4. Dress lumber, S4S, unless otherwise indicated.
- C. Maximum Moisture Content:
 - 1. Boards: 15 percent.
 - 2. Dimension Lumber: 15 percent unless otherwise indicated.

2.2 FIRE-RETARDANT-TREATED LUMBER

- A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

- B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.
 - 1. Treatment is not to promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.
- C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent.[**Kiln-dry plywood after treatment to maximum moisture content of 15 percent.**]
- D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency and other information required by authorities having jurisdiction.
 - 1. For exposed lumber indicated to receive a stained or natural finish, [**mark end or back of each piece**] [**or**] [**omit marking and provide certificates of treatment compliance issued by testing agency**].
- E. For exposed items indicated to receive a stained or natural finish, chemical formulations are not to bleed through, contain colorants, or otherwise adversely affect finishes.
- F. Application: Treat items indicated on Drawings, and the following:
 - 1. Wood cants, nailers, curbs, equipment support bases, blocking, and similar members in connection with roofing.
 - 2. Plywood backing panels.

2.3 MISCELLANEOUS LUMBER

- A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:
 - 1. Blocking.
 - 2. Nailers.
- B. Dimension Lumber Items: Construction or No. 2 grade lumber of the following species:
 - 1. Spruce-pine-fir; NLGA.
 - 2. Spruce-pine-fir (south); NeLMA, WCLIB, or WWPA.
- C. Concealed Boards: 15 percent maximum moisture content and [**any of**] the following species and grades:
 - 1. Spruce-pine-fir (south) or spruce-pine-fir; Construction or No. 2 Common grade; NeLMA, NLGA, WCLIB, or WWPA.
- D. Roofing Nailers: Structural- or No. 2-grade lumber or better; kiln-dried Douglas fir, southern pine, or wood having similar decay-resistant properties.
- E. For blocking not used for attachment of other construction, Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

- F. For furring strips for installing plywood or hardboard paneling, select boards with no knots capable of producing bent-over nails and damage to paneling.

2.4 PLYWOOD BACKING PANELS

- A. Equipment Backing Panels: Plywood, DOC PS 1, Exterior, A-C , fire-retardant treated, in thickness indicated or, if not indicated, not less than 3/4-inch (19-mm) nominal thickness.

2.5 FASTENERS

- A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.
 - 1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M or ASTM F2329 of Type 304 stainless steel.
 - 2. For redwood, use brass/bronze stainless steel hot-dip galvanized-steel fasteners.
- B. Nails, Brads, and Staples: ASTM F1667.
- C. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.
- D. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC01 ICC-ES AC508 ICC-ES AC193 ICC-ES AC308 as appropriate for the substrate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.
- B. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.
- C. Install plywood backing panels by fastening to studs; coordinate locations with utilities requiring backing panels. [**Install fire-retardant-treated plywood backing panels with classification marking of testing agency exposed to view.**]
- D. Install sill sealer gasket/termite barrier in accordance with manufacturer's written instructions at the underside of wall bottom track or rim track and at the top of foundation wall or slab at stud or joist locations.
- E. Do not splice structural members between supports unless otherwise indicated.
- F. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.

1. Provide metal clips for fastening gypsum board or lath at corners and intersections where framing or blocking does not provide a surface for fastening edges of panels. Space clips not more than 16 inches (406 mm) o.c.
- G. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:
1. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches (2438 mm) o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.
 2. Fire block concealed spaces of wood-framed walls and partitions at each floor level, at ceiling line of top story, and at not more than 96 inches (2438 mm) o.c. Where fire blocking is not inherent in framing system used, provide closely fitted solid wood blocks of same width as framing members and 2-inch nominal (38-mm actual) thickness.
 3. Fire block concealed spaces between floor sleepers with same material as sleepers to limit concealed spaces to not more than 100 sq. ft. (9.3 sq. m) and to solidly fill space below partitions.
 4. Fire block concealed spaces behind combustible cornices and exterior trim at not more than 20 feet (6 m) o.c.
- H. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.
- I. Comply with AWPAC M4 for applying field treatment to cut surfaces of preservative-treated lumber.
1. Use inorganic boron for items that are continuously protected from liquid water.
 2. Use copper naphthenate for items not continuously protected from liquid water.
- J. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.
- K. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:
1. Table 2304.10.1, "Fastening Schedule," in ICC's International Building Code (IBC).
 2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.
 3. ICC-ES evaluation report for fastener.
- L. Securely attach roofing nailers to substrates by anchoring and fastening to withstand bending, shear, or other stresses imparted by Project wind loads and fastener-resistance loads as designed in accordance with ASCE/SEI 7.
- M. Use steel common nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood. Drive nails snug but do not countersink nail heads unless otherwise indicated.

3.2 INSTALLATION OF WOOD BLOCKING AND NAILERS

- A. Install where indicated and where required for[**screeding or**] attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.
- B. Attach wood blocking to substrates to support applied loading. Recess bolts and nuts flush with surfaces unless otherwise indicated.
- C. Attach wood roofing nailers securely to substrate to resist the designed outward and upward wind loads indicated on Drawings and in accordance with ANSI/SPRI ED-1, Tables A6 and A7.
- D. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-1/2 inches (38 mm) wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

3.3 PROTECTION

- A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION

SECTION 06 1600 - SHEATHING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Roof sheathing.
- B. Related Requirements:
 - 1. Section 06 1000 "Rough Carpentry" for plywood backing panels.

1.2 PRE-INSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review air-barrier and water-resistant glass-mat gypsum sheathing requirements and installation, special details, transitions, mockups, air-leakage testing, protection, and work scheduling that covers air-barrier and water-resistant glass-mat gypsum sheathing.

1.3 ACTION SUBMITTALS

- A. Product Data Submittals: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.
 - 1. Include data for wood-preserved treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Indicate type of preservative used and net amount of preservative retained.
 - 2. Include data for fire-retardant treatment from chemical treatment manufacturer and certification by treating plant that treated plywood complies with requirements. Include physical properties of treated materials.
 - 3. For fire-retardant treatments, include physical properties of treated plywood both before and after exposure to elevated temperatures, based on testing by a qualified independent testing agency in accordance with ASTM D5516.
 - 4. For products receiving waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.
 - 5. For air-barrier and water-resistant glass-mat gypsum sheathing, include manufacturer's technical data and tested physical and performance properties of products.
- B. Sustainable Design Submittals:
 - 1. Chain-of-Custody Certificates: For certified wood products. Include statement of costs.
 - 2. Chain-of-Custody Qualification Data: For manufacturer and vendor.
 - 3. Laboratory Test Reports: For composite wood products, indicating compliance with requirements for low-emitting materials.
 - 4. Product Data: For installation adhesives, indicating VOC content.
 - 5. Laboratory Test Reports: For installation adhesives, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: For air-barrier and water-resistant glass-mat gypsum sheathing assemblies.
 - 1. Show locations and extent of sheathing, accessories, and assemblies specific to Project conditions.
 - 2. Include details for sheathing joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.

3. Include details of interfaces with other materials that form part of air barrier.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer of air-barrier and water-resistant glass-mat gypsum sheathing.
 1. Installer is to be licensed by ABAA in accordance with ABAA's Quality Assurance Program and is to employ ABAA-certified installers and supervisors on Project.
- B. Testing Agency Qualifications:
 1. For testing agency providing classification marking for fire-retardant-treated material, an inspection agency acceptable to authorities having jurisdiction that periodically performs inspections to verify that the material bearing the classification marking is representative of the material tested.
 2. For testing and inspecting agency providing tests and inspections related to air-barrier and water-resistant glass-mat gypsum sheathing: an independent agency, qualified in accordance with ASTM E329 for testing indicated, and certified by Air Barrier Association of America, Inc.
- C. Certified Wood: Provide an invoice including vendor's chain-of-custody number, product cost, and entity being invoiced.
- D. Vendor Qualifications: A vendor that is certified for chain of custody by an FSC-accredited certification body.
- E. Provide the following upon request:
 1. Qualification Data: For Installer[, **including list of ABAA-certified installers and supervisors employed by Installer, who work on Project**] [and] [testing and inspecting agency].
 2. Product Certificates: From air-barrier and water-resistant glass-mat gypsum sheathing manufacturer, certifying compatibility of sheathing accessory materials with Project materials that connect to or that come in contact with the sheathing.
 3. Product Test Reports: For each air-barrier and water-resistant glass-mat gypsum sheathing assembly, indicating compliance with specified requirements, for tests performed by a qualified testing agency.
 4. Evaluation Reports: For the following, from ICC-ES:
 - a. Wood-preservative-treated plywood.
 - b. Fire-retardant-treated plywood.
 - c. Foam-plastic sheathing.
 - d. Air-barrier and water-resistant glass-mat gypsum sheathing.
 5. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Stack panels flat with spacers beneath and between each bundle to provide air circulation. Protect sheathing from weather by covering with waterproof sheeting, securely anchored. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance Ratings: As tested in accordance with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Fire-Resistance Ratings: Indicated by design designations from UL's "Fire Resistance Directory" or from the listings of another qualified testing agency.
- B. Air-Barrier and Water-Resistant Glass-Mat Gypsum Sheathing Performance: Air-barrier and water-resistant glass-mat gypsum sheathing assembly, and seals with adjacent construction, are to be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies are to be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations[, **tie-ins to installed waterproofing**] [, **tie-ins to other installed air barriers**], and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

2.2 WOOD PANEL PRODUCTS

- A. Certified Wood: The following wood products shall comply with requirements of ASTM D7612-10 (FSC, SFI, ATSM, CSA or PEFC certifications are acceptable).
 - 1. Plywood.
 - 2. Oriented strand board.
 - 3. Particleboard underlayment.
 - 4. Hardboard underlayment.
- B. Thickness: As needed to comply with requirements specified, but not less than thickness indicated.
- C. Factory mark panels to indicate compliance with applicable standard.

2.3 FIRE-RETARDANT-TREATED PLYWOOD

- A. General: Where fire-retardant-treated materials are indicated, use materials complying with requirements in this article that are acceptable to authorities having jurisdiction and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.
- B. Fire-Retardant-Treated Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested in accordance with ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.
 - 1. Use treatment that does not promote corrosion of metal fasteners.
 - 2. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated plywood by pressure process after being subjected to accelerated weathering in accordance with ASTM D2898. Use for exterior locations and where indicated.

- C. Kiln-dry material after treatment to a maximum moisture content of 15 percent. Do not use material that is warped or does not comply with requirements for untreated material.
- D. Identify fire-retardant-treated plywood with appropriate classification marking of qualified testing agency.

2.4 ROOF SHEATHING

- A. Plywood Sheathing, Roofs: , Exposure 1, Structural I sheathing.
 - 1. Span Rating: Not less than 16/0 .
 - 2. Nominal Thickness: Not less than 15/32 inch (11.9 mm) .

2.5 FASTENERS

- A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture.
 - 1. For roof sheathing, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M .
 - 2. For roof parapet wall sheathing, provide fasteners with organic-polymer or other corrosion-protective coating having a salt-spray resistance of more than 800 hours in accordance with ASTM B117.
- B. Nails, Brads, and Staples: ASTM F1667.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Do not use materials with defects that impair quality of sheathing or pieces that are too small to use with minimum number of joints or optimum joint arrangement. Arrange joints so that pieces do not span between fewer than three support members.
- B. Cut panels at penetrations, edges, and other obstructions of work; fit tightly against abutting construction unless otherwise indicated.
- C. Securely attach to substrate by fastening as indicated, complying with the following:
 - 1. Table 2304.10.1, "Fastening Schedule," in the ICC's International Building Code.
 - 2. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in the ICC's International Residential Code for One- and Two-Family Dwellings.
 - 3. ICC-ES evaluation report for fastener.
- D. Use common wire nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections. Install fasteners without splitting wood.
- E. Coordinate [wall] [parapet] [and] [roof] sheathing installation with flashing and joint-sealant installation so these materials are installed in sequence and manner that prevent exterior moisture from passing through completed assembly.

- F. Do not bridge building expansion joints; cut and space edges of panels to match spacing of structural support elements.
- G. Coordinate sheathing installation with installation of materials installed over sheathing so sheathing is not exposed to precipitation or left exposed at end of the workday when rain is forecast.

3.2 INSTALLATION OF WOOD STRUCTURAL PANEL

- A. General: Comply with applicable recommendations in APA Form No. E30, "Engineered Wood Construction Guide," for types of structural-use panels and applications indicated.
- B. Fastening Methods: Fasten panels as indicated below:
 - 1. Wall and Roof Sheathing:
 - a. **[Nail] [Nail or staple]** to wood framing.[**Apply a continuous bead of glue to framing members at edges of wall sheathing panels.**]
 - b. Screw to cold-formed metal framing.
 - c. Space panels 1/8 inch (3 mm) apart at edges and ends.

3.3 INSTALLATION OF HARDBOARD UNDERLAYMENT

- A. Comply with CPA's recommendations and hardboard manufacturer's written instructions for preparing and applying hardboard underlayment.
 - 1. Fastening Method: **[Nail] [Nail or staple]** underlayment to subflooring.

3.4 COMPOSITE NAIL BASE INSULATED ROOF SHEATHING INSTALLATION

- A. Mechanically fasten sheathing to deck in accordance with sheathing manufacturer's instructions.
- B. On metal deck, place boards perpendicular to flutes with sheathing ends bearing on deck flutes.
- C. Lay boards with edges in moderate contact without forcing. Cut sheathing to fit neatly to perimeter blocking and around penetrations through roof. Fill voids over 3/8 inch wide with scrap insulation.
- D. Do not apply more sheathing than can be covered with underlayment in same day.

3.5 FIELD QUALITY CONTROL

- A. ABAA Quality Assurance Program: Perform examinations, preparation, installation, testing, and inspections under ABAA's Quality Assurance Program.
- B. Testing and Inspecting Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Inspections: Air-barrier and water-resistant glass-mat gypsum sheathing, accessories, and installation are subject to inspection for compliance with requirements.[**Inspections may include the following:**]
 - 1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.

2. Laps in strips and transition strips have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
 3. Termination mastic has been applied on cut edges.
 4. Strips and transition strips have been firmly adhered to substrate.
 5. Compatible materials have been used.
 6. Transitions at changes in direction and structural support at gaps have been provided.
 7. Connections between assemblies (sheathing and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
 8. All penetrations have been sealed.
- D. Tests: As determined by testing agency from among the following tests:
1. Air-Leakage-Location Testing: Air-barrier sheathing assemblies will be tested for evidence of air leakage in accordance with [**ASTM E1186, chamber pressurization or depressurization with smoke tracers**] [**ASTM E1186, chamber depressurization using detection liquids**] <Insert requirement>.
 2. Air-Leakage-Volume Testing: Air-barrier assemblies will be tested for air-leakage rate in accordance with [**ASTM E783**] [**or**] [**ASTM E2357**].
- E. Air barriers will be considered defective if they do not pass tests and inspections.
- F. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
- G. Prepare test and inspection reports.

END OF SECTION

SECTION 06 4116 - PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Plastic-laminate-clad architectural cabinets.
 - 2. Cabinet hardware and accessories.
 - 3. Miscellaneous materials.
- B. Related Requirements:
 - 1. Section 06 1000 "Rough Carpentry" for wood furring, blocking, shims, and hanging strips required for installing cabinets that are concealed within other construction before cabinet installation.

1.2 COORDINATION

- A. Coordinate sizes and locations of framing, blocking, furring, reinforcements, and other related units of Work specified in other Sections to support loads imposed by installed and fully loaded cabinets.
- B. Hardware Coordination: Distribute copies of approved hardware schedule specified in to manufacturer of architectural cabinets; coordinate Shop Drawings and fabrication with hardware requirements.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
- B. Sustainable Design Submittals:
 - 1. Chain-of-Custody Certificates: For certified wood products. Include statement of costs.
 - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 3. Laboratory Test Reports: For composite wood products, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Show large-scale details.
 - 3. Show locations and sizes of furring, blocking, and hanging strips, including concealed blocking and reinforcement specified in other Sections.
 - 4. Show locations and sizes of cutouts and holes for items installed in plastic-laminate architectural cabinets.
 - 5. Apply Program label to Shop Drawings.

- D. Samples: For each exposed product and for each color and texture specified, in manufacturer's or manufacturer's standard size.
- E. Samples for Initial Selection: For each type of exposed finish.
- F. Samples for Verification: For the following:
 - 1. Plastic Laminates: 8 by 10 inches (200 by 250 mm), for each type, color, pattern, and surface finish required.
 - a. Provide one sample applied to core material with specified edge material applied to one edge.
 - 2. Thermally Fused Laminate (TFL) Panels: 8 by 10 inches (200 by 250 mm), for each color, pattern, and surface finish.
 - a. Provide edge banding on one edge.
 - 3. Corner Pieces:
 - a. Cabinet-front frame joints between stiles and rails and at exposed end pieces, 18 inches (450 mm) high by 18 inches (450 mm) wide by 6 inches (150 mm) deep.
 - b. Miter joints for standing trim.
 - 4. Exposed Cabinet Hardware and Accessories: One full-size unit for each type and finish.

1.5 CLOSEOUT SUBMITTALS

- A. Quality Standard Compliance Certificates: certificates.

1.6 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Employs skilled workers who custom fabricate products similar to those required for this Project and whose products have a record of successful in-service performance.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build mockups of typical architectural cabinets as shown on Drawings.
 - 2. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. Provide the following upon request:
 - 1. Qualification Data: For manufacturer and Installer.
 - 2. Product Certificates: For the following:
 - a. Composite wood products.
 - b. Thermally fused laminate panels.
 - c. High-pressure decorative laminate.
 - d. Adhesives.
 - 3. Evaluation Reports: For fire-retardant-treated materials, from ICC-ES.
 - 4. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver cabinets until painting and similar finish operations that might damage architectural cabinets have been completed in installation areas. Store cabinets in installation areas or in areas where environmental conditions comply with requirements specified in "Field Conditions" Article.

1.8 FIELD CONDITIONS

- A. Environmental Limitations without Humidity Control: Do not deliver or install cabinets until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature and relative humidity at levels planned for building occupants during the remainder of the construction period.
- B. Environmental Limitations with Humidity Control: Do not deliver or install cabinets until building is enclosed, wet-work is complete, and HVAC system is operating and maintaining temperature between 60 and 90 deg F (16 and 32 deg C) and relative humidity between 25 and 55 percent during the remainder of the construction period.
- C. Field Measurements: Where cabinets are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication, and indicate measurements on Shop Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.
 - 1. Locate concealed framing, blocking, and reinforcements that support cabinets by field measurements before being enclosed/concealed by construction, and indicate measurements on Shop Drawings.
- D. Established Dimensions: Where cabinets are indicated to fit to other construction, establish dimensions for areas where cabinets are to fit. Provide allowance for trimming at site, and coordinate construction to ensure that actual dimensions correspond to established dimensions.

PART 2 - PRODUCTS

2.1 PLASTIC-LAMINATE-CLAD ARCHITECTURAL CABINETS

- A. Architectural Woodwork Standards Grade: Custom .
- B. Regional Materials: Wood products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- C. Certified Wood: Wood products shall comply with requirements of ASTM D7612-10 (FSC, SFI, ATSM, CSA or PEFC certifications are acceptable).
- D. Type of Construction: Frameless .
- E. Door and Drawer-Front Style: Flush overlay.
- F. High-Pressure Decorative Laminate (PL-01): ISO 4586-3, grades as indicated or if not indicated, as required by quality standard.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Formica Corporation.
 - b. Pionite; a Panolam Industries International, Inc. brand.
 - c. Wilsonart LLC.

G. Exposed Surfaces:

1. Plastic-Laminate Grade: VGS .
2. Edges: Grade VGS .
3. Pattern Direction: As indicated.

H. Semiexposed Surfaces:

1. Surfaces Other Than Drawer Bodies: .
 - a. Edges of Plastic-Laminate Shelves: PVC tape, 0.018-inch (0.460-mm) minimum thickness, matching laminate in color, pattern, and finish .
 - b. Edges of Thermally Fused Laminate Panel Shelves: PVC or polyester edge banding.
 - c. For semiexposed backs of panels with exposed plastic-laminate surfaces, provide surface of high-pressure decorative laminate, ISO 4586-3, grade to match exposed surface.
2. Drawer Sides and Backs: Thermally fused laminate panels with PVC or polyester edge banding.
3. Drawer Bottoms: Thermally fused laminate panels.

I. Drawer Construction: Fabricate with exposed fronts fastened to subfront with mounting screws from interior of body.

1. Join subfronts, backs, and sides with glued rabbeted joints supplemented by mechanical fasteners .

2.2 WOOD MATERIALS

A. Wood Products: Provide materials that comply with requirements of referenced quality standard for each type of architectural cabinet and quality grade specified unless otherwise indicated.

1. Wood Moisture Content: 5 to 10 8 to 13 4 to 9 percent.

2.3 CABINET HARDWARE AND ACCESSORIES

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Accuride International Inc.
 - b. Grass America.
 - c. Julius Blum & Co., Inc.
 - d. Knappe & Vogt Manufacturing Company.

B. Frameless Concealed Hinges (European Type): ANSI/BHMA A156.9, B01602, 135 degrees of opening, self-closing.

C. Wire Pulls: Back mounted, solid metal , 5 inches (127 mm) long, 2-1/2 inches (63.5 mm) deep, and 5/16 inch (8 mm) in diameter.

- D. Adjustable Shelf Standards and Supports: ANSI/BHMA A156.9, B04071; with shelf rests, B04081 .
- E. Shelf Rests: ANSI/BHMA A156.9, B04013; metal .
- F. Drawer Slides: ANSI/BHMA A156.9.
 - 1. Heavy-Duty (Grade 1HD-100 and Grade 1HD-200): Side mount .
 - a. Type: Full overtravel extension.
 - b. Material: Stainless steel slides.
 - c. Motion Feature: Self-closing mechanism.
- G. Exposed Hardware Finishes: For exposed hardware, provide finish that complies with ANSI/BHMA A156.18 for ANSI/BHMA finish number indicated.
 - 1. Dark, Oxidized, Satin Bronze, Oil Rubbed: ANSI/BHMA 613 for bronze base; ANSI/BHMA 640 for steel base; match Architect's sample.
- H. For concealed hardware, provide manufacturer's standard finish that complies with product class requirements in ANSI/BHMA A156.9.

2.4 MISCELLANEOUS MATERIALS

- A. Furring, Blocking, Shims, and Hanging Strips: Softwood or hardwood lumber , kiln-dried to less than 15 percent moisture content.
- B. Anchors: Select material, type, size, and finish required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.
- C. Adhesives: Use adhesives that meet the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- D. Adhesive for Bonding Plastic Laminate: Type I, waterproof type as selected by fabricator to comply with requirements.
 - 1. Adhesive for Bonding Edges: Hot-melt adhesive[**or adhesive specified above for faces**].

2.5 FABRICATION

- A. Fabricate architectural cabinets to dimensions, profiles, and details indicated.
- B. Complete fabrication, including assembly and hardware application, to maximum extent possible before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.
 - 1. Notify Architect seven days in advance of the dates and times architectural cabinet fabrication will be complete.

2. Trial fit assemblies at manufacturer's shop that cannot be shipped completely assembled. Install dowels, screws, bolted connectors, and other fastening devices that can be removed after trial fitting. Verify that various parts fit as intended and check measurements of assemblies against field measurements before disassembling for shipment.
- C. Shop-cut openings to maximum extent possible to receive hardware, appliances, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.
- D. Install glass to comply with applicable requirements in Section 08 8000 "Glazing" and in GANA's "Glazing Manual."
 1. For glass in frames, secure glass with removable stops.
 2. For exposed glass edges, polish and grind smooth.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Before installation, condition cabinets to humidity conditions in installation areas for not less than 72 hours.

3.2 INSTALLATION

- A. Architectural Woodwork Standards Grade: Install cabinets to comply with quality standard grade of item to be installed.
- B. Assemble cabinets and complete fabrication at Project site to extent that it was not completed in the shop.
- C. Anchor cabinets to anchors or blocking built in or directly attached to substrates. Secure with wafer-head cabinet installation screws.
- D. Install cabinets level, plumb, and true in line to a tolerance of 1/8 inch in 96 inches (3 mm in 2400 mm) using concealed shims.
 1. Scribe and cut cabinets to fit adjoining work, refinish cut surfaces, and repair damaged finish at cuts.
 2. Install cabinets without distortion so doors and drawers fit openings and are accurately aligned. Adjust hardware to center doors and drawers in openings and to provide unencumbered operation. Complete installation of hardware and accessory items as indicated.
 3. Fasten wall cabinets through back, near top and bottom, and at ends not more than 16 inches (400 mm) o.c. with No. 10 wafer-head sheet metal screws through metal backing or metal framing behind wall finish.

3.3 FIELD QUALITY CONTROL

- A. Inspections: Provide inspection of installed Work through certifying that woodwork, including installation, complies with requirements of the Architectural Woodwork Standards for the specified grade.

1. Inspection entity is to prepare and submit report of inspection.

3.4 ADJUSTING AND CLEANING

- A. Repair damaged and defective cabinets, where possible, to eliminate functional and visual defects. Where not possible to repair, replace architectural cabinets. Adjust joinery for uniform appearance.
- B. Clean, lubricate, and adjust hardware.
- C. Clean cabinets on exposed and semiexposed surfaces.

END OF SECTION

FOR REFERENCE ONLY

SECTION 07 1326 - SELF-ADHERING SHEET WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pre-Applied Waterproofing Membrane.
 - 2. Post-Applied Waterproofing Membrane.
 - 3. Molded-sheet drainage panels.
 - 4. Insulation.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, adhesion to contaminated substrate (e.g. concrete curing compounds and form release agents), substrate curing period weather related restrictions during installation, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs. Include the following:
 - a. Before starting application of membrane waterproofing work, arrange a job-site meeting with the Architect, the Testing Agency and manufacturer representative to discuss the following:
 - 1) The waterproofing system, number of plies, termination and flashing requirements.
 - 2) Intermediate and final requirements of protecting the work.
 - 3) The different substrates that will receive the waterproofing and preparation requirements for each.
 - 4) Curing requirements for concrete.
 - 5) Concrete form release agent precautions.
 - 6) Verify admixtures and compatibility with waterproofing manufacturer.
 - 7) Adhering to coated surfaces, if applicable.
 - 8) Job specific recommendations on use of primers.
 - 9) Hot, cold and wet condition precautions.
 - 10) Scheduling and coordination with other construction, such as waterproofing overlaps that must be installed during construction of walls and footings both above and below grade.
 - 11) Protection of the work and repair procedures.
 - 12) Verify in writing to the Owner's representative, that the Contractor's full time on site foreman and crew etc. (as required) are certified, or meet the requirements of the manufacturer of the waterproofing, as installers.
 - b. Whenever the membrane waterproofing work is to be done, notify Testing Agency in sufficient time to arrange inspections.
 - c. Provide safe access to the location of the Work for proper inspection.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, and tested physical and performance properties of waterproofing.

2. Include manufacturer's written instructions for evaluating, preparing, and treating substrate.

- B. Shop Drawings: Show locations and extent of waterproofing and details of substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions. Include project specific details to demonstrate implementation of the waterproofing scope.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by waterproofing manufacturer.
- B. Testing Agency: An approved company by the waterproofing manufacturer to provide independent observations for quality control and compliance with material and labor warranty requirements.
- C. Provide the following upon request:
 1. Qualification Data: For Installer.
 2. Qualification Data: For Testing Agency.
 3. Field quality-control reports.
- D. In-situ Pre-Applied Waterproofing Mockups: Build for each typical waterproofing installation including accessories to demonstrate surface preparation, crack and joint treatment, corner treatment, and protection.
 1. Size: 100 sq. ft. in area.
 2. Description: Each type of wall installation.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- E. In-situ Post-Applied Waterproofing Mockups: Build for each typical waterproofing installation including accessories to demonstrate surface preparation, crack and joint treatment, corner treatment, and protection.
 1. Size: 100 sq. ft. in area.
 2. Description: Each type of wall installation.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate.
 1. Do not apply waterproofing in snow, rain, fog, or mist.

- B. Maintain adequate ventilation during preparation and application of waterproofing materials.
- C. Compatibility:
 - 1. Where new work interfaces existing waterproofed construction, remove existing waterproofing as required to install new work. Interface new waterproofing with existing system to provide continuous system without leaks. Ensure compatibility of system materials.
 - 2. The waterproofing manufacturer shall submit a letter stating compatibility or concerns with existing, or adjacent, waterproofing.

1.6 WARRANTY

- A. Pre-Applied and Post-Applied Sheet Waterproofing Manufacturer's Watertightness Warranty: Manufacturer's material and labor warranty in which manufacturer agrees to cover labor and to furnish replacement waterproofing material for waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.
 - 1. Warranty Period: Fifteen years from date of Substantial Completion.
 - 2. Warranty Requirements:
 - a. Single source materials or materials approved by primary waterproofing manufacturer.
 - b. Pre-Installation Conference.
 - 3. Installation inspected by Testing Agency, minimum four phases of blindside installation for substrate, waterproofing installation, observation after reinforcement, and final inspection prior to concrete placement.
- B. Installer Warranty: Approved installer agrees to provide labor as part of waterproofing watertightness warranty complying with manufacturer's requirements for minimum of two years.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Source Limitations for Waterproofing System: Obtain waterproofing materials, protection course, and molded-sheet drainage panels from single source from single manufacturer.

2.2 POST-APPLIED SHEET WATERPROOFING

- A. Modified Bituminous Sheet: Minimum 60-mil (1.5-mm) nominal thickness, self-adhering sheet consisting of 56 mils (1.4 mm) of rubberized asphalt laminated on one side to a 4-mil- (0.10-mm-) thick, polyethylene-film reinforcement, and with release liner on adhesive side; formulated for application with primer that complies with VOC limits of authorities having jurisdiction.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. AVM Industries; 580-PL.
 - b. CETCO; Envirosheet.
 - c. GCP Applied Technologies Inc.; Bituthene 3000/Low Temperature.
 - 2. Application: Two (2) layers.

2.3 PRE-APPLIED SHEET WATERPROOFING

- A. Adhesive-Coated HDPE Sheet for Blindside Vertical Applications: Uniform, flexible, multilayered-composite sheet membrane consisting of an HDPE film coated with pressure-sensitive adhesive layers. The membrane is designed to create a permanent bond to poured concrete to prevent water migration at the interface of the membrane and structural concrete; with 0.075-inch minimum nominal thickness of the composite sheet membrane.
 - 1. AVM Industries; Aussie Skin 550G Single System.
- B. Adhesive-Coated HDPE Sheet for Blindside Vertical Applications: Uniform, flexible, multilayered-composite sheet membrane consisting of an HDPE film coated with a pressure-sensitive adhesive and protective release liner, total 46-mil (0.8-mm) thickness; with the following physical properties:
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. GCP Applied Technologies; Preprufe 300R Plus.
- C. Thermoplastic Sheet for Blindside Horizontal and Vertical Applications: 60 mil (1.5 mm) nominal thick PVC, Elvaloy KEE thermoplastic membrane reinforced with a 5.0 oz. weft inserted knit polyester fabric integrally bonded to an Active Polymer Core (APC).
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. CETCO; CoreFlex 60.

2.4 AUXILIARY MATERIALS

- A. General: Furnish auxiliary materials recommended by waterproofing manufacturer for intended use and compatible with sheet waterproofing.
 - 1. Furnish liquid-type auxiliary materials that comply with VOC limits of authorities having jurisdiction.
- B. Primer: Liquid primer recommended for substrate by sheet-waterproofing material manufacturer.
- C. Liquid Membrane: Elastomeric, two-component liquid, cold fluid applied, of trowel grade or low viscosity.
- D. Substrate Patching Membrane: Low-viscosity, two-component, modified asphalt coating.
- E. Sheet Strips: Self-adhering, rubberized-asphalt sheet strips of same material and thickness as sheet waterproofing.
- F. Mastic, Adhesives, and Detail Tape: Liquid mastic and adhesives, and adhesive tapes recommended by waterproofing manufacturer.
 - 1. Detail Tape: Two-sided, pressure-sensitive, self-adhering reinforced tape, 4-1/2 inches (114 mm) wide, with a tack-free protective adhesive coating on one side and release film on self-adhering side.
- G. Expansion Joints: Proprietary field fabricated expansion joints shall be used with manufacturers waterproofing or as recommended by the waterproofing manufacturer, unless stated otherwise.
- H. Metal Termination Bars:

1. Termination Bar: Stainless Steel 1 inch by 8 feet, 0.075-inch thick, with 5/16-inch holes 8 inches to 9 inches on center. Basis of design: Advanced Building Products Inc. Stainless Steel Termination Bar.
 2. Expansion Anchor: 1/4-inch x 2-inch expansion anchor consisting of a Type 304 Stainless Steel drive pin and an expanding body. Basis of design: Hilti Metal HIT Anchor.
- I. Protection Course:
1. Protection Board Vertical Applications: Extruded polystyrene board insulation, Type IV, 25 psi (173 kPa) minimum compressive resistance, shiplap edged.
 - a. Products: Subject to compliance with requirements, provide the following:
 - 1) Extruded Polystyrene; Kingspan GreenGuard; Type 4 Insulation Board.
 - b. Adhesive: 3M; Scotch-Weld.
- J. Reinforced Fluid Applied Flashing:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Soprema; Alsan RS 230 Flash System.
- K. Self-Adhering Stainless Steel Flexible Flashing:
1. Subject to compliance with requirements, provide the following:
 - a. York Manufacturing Inc.; York 304 SS
 2. Characteristics:
 - a. Type: stainless steel with one stainless steel face (facing outward) with a butyl block co-polymer adhesive (inward facing).
 - b. Stainless steel: type 304, ASTM A240. Domestically sourced per DF ARS 252.225-7008 and/or DF ARS 252.225-7009.
- 2.5 MOLDED-SHEET DRAINAGE PANELS
- A. Type 1: Nonwoven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite subsurface drainage panel consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a nonwoven, needle-punched geotextile facing with an apparent opening size not exceeding No. 70 (0.21-mm) sieve laminated to one side of the core and a polymeric film bonded to the other side; and with a vertical flow rate of 9 to 18 gpm per ft. (112 to 220 L/min. per m112 to 220 L/min. per m).
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Hydrotech, Inc; Hydrodrain 400.
 - b. American Wick Drain Corporation; Amerdrain 520.
 - c. Carlisle Coatings & Waterproofing; CCW MiraDRAIN 6200.
 - d. GCP Applied Technologies Inc.; Hydroduct 220 (vertical), Hydroduct 660 (horizontal).
 - e. Insulation Solutions, Inc; AquaCheck DB 1500.
 - f. JDR Enterprises, Inc; J-Drain 420.
 - g. Liquid Plastics Inc; Deco-Drain 42.

2.6 INSULATION

- A. XPS – 1: Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) minimum compressive strength; unfaced; square or shiplap edged.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. DiversiFoam Products.
 - 2. Dow Chemical Company (The).
 - 3. Owens Corning. Pactiv Corporation.
 - 4. T. Clear Corporation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the waterproofing.
 - 1. Verify that concrete has cured and aged for minimum time period recommended in writing by waterproofing manufacturer.
 - 2. Verify that substrate is visibly dry and within the moisture limits recommended in writing by manufacturer. Test for capillary moisture by plastic sheet method in accordance with ASTM D 4263.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

- A. Clean, prepare, and treat substrates in accordance with manufacturer's written instructions. Provide clean, dust-free, and dry substrates for waterproofing application.
- B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage and overspray affecting other construction.
- C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
- D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids.
- E. For masonry substrates, apply waterproofing over concrete block and brick with mortar joints struck flush or smooth trowel parge coat.
- F. Prepare, fill, prime, and treat joints and cracks in substrates. Remove dust and dirt from joints and cracks in accordance with ASTM D 4258.
 - 1. Install sheet strips of width in accordance with manufacturer's written instructions and center over treated construction and contraction joints and cracks.

- G. Bridge and cover isolation joints expansion joints and discontinuous deck-to-wall and deck-to-deck joints with overlapping sheet strips of widths in accordance with manufacturer's written instructions.
- H. Corners: Prepare, prime, and treat inside and outside corners in accordance with ASTM D 6135.
 - 1. Install membrane strips centered over vertical inside corners. Install 3/4-inch (19-mm) fillets of liquid membrane on horizontal inside corners and as follows:
 - a. At footing-to-wall intersections, extend liquid membrane in each direction from corner or install membrane strip centered over corner.
 - b. At plaza-deck-to-wall intersections, extend liquid membrane or sheet strips onto deck waterproofing and to finished height of sheet flashing.
- I. Prepare, treat, and seal vertical and horizontal surfaces at terminations and penetrations through waterproofing and at drains and protrusions in accordance with ASTM D 6135.

3.3 POST-APPLIED SHEET-WATERPROOFING APPLICATION

- A. Install modified bituminous sheets in accordance with waterproofing manufacturer's written instructions and recommendations in ASTM D 6135.
- B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by sheet waterproofing in same day. Reprime areas exposed for more than 24 hours.
- C. Apply and firmly adhere sheets, 100% back rolled, over area to receive waterproofing. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and end laps. Overlap and seal seams, and stagger end laps to ensure watertight installation.
 - 1. When ambient and substrate temperatures range between 25 and 40 deg F (minus 4 and plus 5 deg C), install self-adhering, modified bituminous sheets produced for low-temperature application. Do not use low-temperature sheets if ambient or substrate temperature is higher than 60 deg F (16 deg C).
- D. Two-Ply Application, as follows:
 - 1. Install detail strips per manufacturer's written installation instructions.
 - 2. Install first ply; install sheets to form a membrane with lap widths of a uniform 2-1/2-inch (64-mm) minimum.
 - 3. Install second ply; install sheets to form a membrane with lap widths of a uniform 2-1/2-inch (64-mm) minimum.
 - 4. Stagger seams of first ply and second ply. Do not align seams of first ply with second ply.
- E. Horizontal Application: Install Two-Ply Application, apply sheets from low to high points of decks to ensure that laps shed water.
- F. Apply continuous sheets over already-installed sheet strips, bridging substrate cracks, construction, and contraction joints.
- G. Seal edges of sheet-waterproofing terminations with mastic.
- H. Install sheet-waterproofing and auxiliary materials to tie into adjacent waterproofing.

- I. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Slit and flatten fishmouths and blisters. Patch with sheet waterproofing extending 6 inches (150 mm) beyond repaired areas in all directions.
- J. Immediately install protection course with butted joints over waterproofing membrane.

3.4 PRE-APPLIED SHEET-WATERPROOFING APPLICATION

- A. Install bonded blindside sheet waterproofing in accordance with manufacturer's written instructions.
- B. Place and secure molded-sheet drainage panels over substrate. Lap edges and ends of geotextile to maintain continuity.
- C. Vertical Applications: Install sheet with face against substrate. Accurately align sheets and maintain uniform side and end laps of minimum dimensions required by membrane manufacturer. Overlap and seal seams, and stagger and tape end laps to ensure watertight installation. Mechanically fasten to substrate.
 - 1. Securely fasten top termination of membrane with continuous metal termination bar anchored into substrate and cover with detailing tape.
- D. Corners: Seal lapped terminations and cut edges of sheet waterproofing at inside and outside corners with detail tape.
- E. Seal penetrations through sheet waterproofing to provide watertight seal with detail tape patches or wraps and a liquid-membrane troweling.
- F. Install sheet-waterproofing and auxiliary materials to produce a continuous watertight tie into adjacent waterproofing.
- G. Repair tears, voids, and lapped seams in waterproofing not complying with requirements. Tape perimeter of damaged or nonconforming area extending 6 inches (150 mm) beyond repaired areas in all directions. Apply a patch of sheet waterproofing and firmly secure with detail tape.

3.5 MOLDED-SHEET DRAINAGE-PANEL INSTALLATION

- A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, in accordance with manufacturer's written instructions. Use adhesives or other methods that do not penetrate waterproofing. Lap edges and ends of geotextile to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.

3.6 INSULATION INSTALLATION

- A. Install one or more layers of board insulation to achieve required thickness over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
- B. On vertical surfaces, set insulation units in adhesive or tape applied in accordance with manufacturer's written instructions.

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Site Representative: Engage a manufacturer's site representative qualified by waterproofing membrane manufacturer to inspect substrate conditions, surface preparation, membrane application, flashings, protection, and drainage components, and to furnish daily reports to Architect.
- B. Testing Agency: Owner to Engage a qualified testing agency to inspect substrate conditions, surface preparation, waterproofing application, protection, and drainage components, and to furnish reports to Architect. Installation inspected by Testing Agency, minimum four phases of blindside installation for substrate, waterproofing installation, observation after reinforcement, and final inspection prior to concrete placement. Testing Agency to comply with requirement for material and labor warranty specified.

3.8 PROTECTION, REPAIR, AND CLEANING

- A. Do not permit foot or vehicular traffic on unprotected membrane.
- B. Protect waterproofing from damage and wear during remainder of construction period.
- C. Protect installed insulation from damage due to UV light, harmful weather exposures, physical abuse, and other causes. Provide temporary coverings where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.
- D. Correct deficiencies in or remove waterproofing that does not comply with requirements; repair substrates, reapply waterproofing, and repair sheet flashings.
- E. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

SECTION 07 1416 - COLD FLUID-APPLIED WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Modified asphalt waterproofing.
 - 2. Molded-sheet drainage panels.
 - 3. Insulation.
- B. Related Section:
 - 1. Section 07 9200 "Joint Sealants" for joint-sealant materials and installation.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include manufacturer's written instructions for evaluating, preparing, and treating substrate, technical data, and tested physical and performance properties of waterproofing.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration (EPD): For each product.
- C. Shop Drawings: Show locations and extent of waterproofing. Include details for substrate joints and cracks, sheet flashings, penetrations, inside and outside corners, tie-ins with adjoining waterproofing, and other termination conditions.
 - 1. Include setting drawings showing layout, sizes, sections, profiles, and joint details of pedestal-supported concrete pavers.
- D. Samples: For the following products:
 - 1. Waterproofing System, 8 by 8 inches (200 by 200 mm), showing layering of membrane components (waterproofing membrane, reinforcing fabric, and protection course).
 - 2. Flashing sheet, 10 by 8 inches (250 by 200 mm).
 - 3. Membrane-reinforcing fabric, 10 by 8 inches (250 by 200 mm).
 - 4. Insulation, 10 by 8 inches (250 by 200 mm).
 - 5. Drainage panel, 4 by 4 inches (100 by 100 mm).

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: A firm that is acceptable to waterproofing manufacturer for installation of waterproofing required for this Project.
- B. Source Limitations: Obtain waterproofing materials from single manufacturer or from manufacturer's approved by selected waterproofing manufacturer.
- C. Provide the following upon request:
 - 1. Qualification Data: For Installer.
 - 2. Product Test Reports: For waterproofing, based on evaluation of comprehensive tests performed by a qualified testing agency.
 - 3. Field quality-control reports.

- D. Mockups: Before beginning installation, install waterproofing to 100 sq. ft. (9.3 sq. m) of wall to demonstrate surface preparation, crack and joint treatment, corner treatment, thickness, texture, and execution quality.
1. For slopes greater than 2:12, mockup is required to test interface shear to determine the stability of the system sandwich.
 2. If Architect determines mockups do not comply with requirements, reapply waterproofing and reinstall overlaying construction until mockups are approved.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- E. Preinstallation Conference: Conduct conference at Project site.
1. Review waterproofing requirements including surface preparation, substrate condition and pretreatment, adhesion to contaminated substrate (e.g. concrete curing compounds and form release agents), substrate curing period weather related restrictions during installation, special details and sheet flashings, installation procedures, testing and inspection procedures, and protection and repairs.
 - a. Before starting application of membrane waterproofing work, arrange a job-site meeting with the Architect, the Testing Agency and manufacturer representative to discuss the following:
 - 1) The waterproofing system, number of plies, termination and flashing requirements.
 - 2) Intermediate and final requirements of protecting the work.
 - 3) The different substrates that will receive the waterproofing and preparation requirements for each.
 - 4) Curing requirements for concrete.
 - 5) Concrete form release agent precautions.
 - 6) Verify admixtures and compatibility with waterproofing manufacturer.
 - 7) Adhering to coated surfaces, if applicable.
 - 8) Job specific recommendations on use of primers.
 - 9) Hot, cold and wet condition precautions.
 - 10) Scheduling and coordination with other construction, such as waterproofing overlaps that must be installed during construction of walls and footings both above and below grade.
 - 11) Protection of the work and repair procedures.
 - 12) Verify in writing to the Owner's representative, that the Contractor's full time on site foreman and crew etc. (as required) are certified, or meet the requirements of the manufacturer of the waterproofing, as installers.
 - b. Whenever the membrane waterproofing work is to be done, notify Testing Agency in sufficient time to arrange inspections.
 - c. Provide safe access to the location of the Work for proper inspection.
 - d. Post installation testing (e.g. Flood Testing or Electronic Field Vector Mapping.)

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver liquid materials to Project site in original containers with seals unbroken, labeled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.

- B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by waterproofing manufacturer.
- C. Remove and replace liquid materials that cannot be applied within their stated shelf life.
- D. Protect stored materials from direct sunlight.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Apply waterproofing within the range of ambient and substrate temperatures recommended by waterproofing manufacturer. Do not apply waterproofing to a damp or wet substrate, when relative humidity exceeds 85 percent, or when temperatures are less than 5 deg F (3 deg C) above dew point.
 - 1. Do not apply waterproofing in snow, rain, fog or mist, or when such weather conditions are imminent during application and curing period.
- B. Maintain adequate ventilation during application and curing of waterproofing materials.
- C. Compatibility:
 - 1. Where new work interfaces existing waterproofed construction, remove existing waterproofing as required to install new work. Interface new waterproofing with existing system to provide continuous system without leaks. Ensure compatibility of system materials.
 - 2. The waterproofing manufacturer shall submit a letter stating compatibility or concerns with existing, or adjacent, waterproofing.

1.6 WARRANTY

- A. Special Manufacturer's Warranty: Manufacturer's standard form in which waterproofing manufacturer and Installer agree to repair or replace waterproofing that does not comply with requirements or that fails to remain watertight within specified warranty period.
 - 1. Warranty does not include failure of waterproofing due to failure of substrate prepared and treated in accordance with requirements or formation of new joints and cracks in substrate that exceed 1/16 inch (1.6 mm) in width.
 - 2. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 WATERPROOFING

- A. Modified Asphalt Waterproofing: 55 mil thick sheet consisting of rubber modified asphalt filmed onto a woven glass or polyester fabric, set in a fluid applied proprietary adhesive to form a monolithic membrane.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Barrett Company; Black Pearl Waterproofing.
 - b. Laureco Waterproofing, Inc.

2.2 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials recommended by manufacturer to be compatible with one another and with waterproofing, as demonstrated by waterproofing manufacturer, based on testing and field experience.
- B. Primer: Manufacturer's proprietary, factory-formulated primer.
- C. Sheet Flashing: A single ply of modified asphalt membrane waterproofing or 50-mil- (1.3-mm-) minimum, nonstaining, uncured sheet neoprene.
 - 1. Adhesive: Manufacturer's recommended contact adhesive.
- D. Membrane-Reinforcing Fabric: Nonwoven, needle-punched white polyester fabric, manufacturer's standard weight.
- E. Joint Reinforcing Strip: Manufacturer's recommended fiberglass mesh or polyester fabric.
- F. Joint Sealant: Multicomponent polyurethane sealant, compatible with waterproofing, complying with ASTM C 920 Type M, Class 25; Grade NS for sloping and vertical applications or Grade P for deck applications; Use NT exposure; and as recommended by manufacturer for substrate and joint conditions.
 - 1. Backer Rod: Closed-cell polyethylene foam.
- G. Waterproofing Reinforcement: Provide manufacturer's recommended sheet flashing.
- H. Waterproofing Filler: Cementitious or bituminous filler recommended by waterproofing manufacturer for application and substrate.
- I. Waterproofing Flashing: Provide manufacturer's recommended sheet flashing.
- J. Expansion Joints: Proprietary field fabricated expansion joints shall be used with manufacturers waterproofing or as recommended by the waterproofing manufacturer, unless stated otherwise.
- K. Metal Termination Bar: Provide the following components.
 - 1. Termination Bar: Stainless Steel 1 inch by 8 feet, 0.075" thick, with 5/16" holes 8" to 9" on center. Basis of design: Advanced Building Products, Inc. Stainless Steel Termination Bar.
 - 2. Expansion Anchor: 1/4" x 2" expansion anchor consisting of a Type 304 Stainless Steel drive pin and an expanding body. Basis of design: Hilti Metal HIT Anchor.
 - 3. Butyl Sealant Tape: Adco Products, Inc.; ST-30A, or as approved, a 100 percent solids, non-hardening butyl rubber based extruded tape sealant, designed to not shrink or oxidize under long term aging, which will elongate and absorb compression within the sealant without breaking the adhesive bond to the substrate.
 - 4. Mastic: Trowel grade liquid mastic recommended by waterproofing manufacturer.
- L. Self-Adhering Stainless Steel Flexible Flashing:
 - 1. Subject to compliance with requirements, provide the following:
 - a. York Manufacturing Inc.; York 316 SS.
 - 1) Characteristics:

- a) Type: Stainless steel with one stainless steel face (facing outward) with a butyl block co-polymer adhesive (inward facing).
- b) Stainless steel: Type 316, ASTM A240. Domestically sourced per DF ARS 252.225-7008 and/or DF ARS 252.225-7009.

2.3 PROTECTION COURSE

- A. Protection Course Horizontal and Vertical Applications: ASTM D 6506, semirigid sheets of fiberglass or mineral-reinforced-asphaltic core, pressure laminated between two asphalt-saturated fibrous liners, 1/8-inch (3 mm) nominal thickness.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. American Hydrotech, Inc; Hydroflex 30.
 - b. Barrett Company; Ram 200 Heavy Duty Protection Course.
 - c. Carlisle; Protection HS.
 - d. Henry Company; G100 SS.
 - e. Laurenco Waterproofing; Premium Protection Sheet.
 - 2. Adhesive: Rubber-based solvent type recommended by waterproofing manufacturer for type of protection course.

2.4 MOLDED-SHEET DRAINAGE PANELS

- A. Type 2: Woven-Geotextile-Faced, Molded-Sheet Drainage Panel: Composite subsurface drainage panels consisting of a studded, nonbiodegradable, molded-plastic-sheet drainage core; with a woven-geotextile facing with an apparent opening size not exceeding No. 45 (0.43-mm) sieve, laminated to one side of the core, with a polymeric film bonded to the other side; and with a horizontal flow rate of not less than 2.8 gpm per ft. (35 L/min. per m).
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Hydrotech, Inc; Hydrodrain 700.
 - b. American Wick Drain Corporation; Amerdrain 650.
 - c. Carlisle Coatings & Waterproofing, Inc; CCW MiraDRAIN 9000.
 - d. GCP Applied Technologies; Hydroduct 225.
 - e. JDR Enterprises, Inc.; J-Drain 700.

2.5 INSULATION

- A. Type XPS — 1: Board Insulation: Extruded-polystyrene board insulation complying with ASTM C 578, Type VI, 40-psi (276-kPa) minimum compressive strength; unfaced; square or shiplap edged.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. DiversiFoam Products.
 - b. Dow Chemical Company (The).
 - c. Owens Corning. Pactiv Corporation.
 - d. T. Clear Corporation.

PART 3 - EXECUTION

3.1 GENERAL

- A. Comply with waterproofing manufacturer's written recommendations and warranty requirements.

3.2 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance.
 - 1. Verify that concrete has cured and aged for minimum time period recommended by waterproofing manufacturer.
 - 2. Perform testing as required by waterproofing manufacturer for test type, rate, and quantity to validate that substrate is acceptable, dry, and free of moisture.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 SURFACE PREPARATION

- A. Clean and prepare substrate in accordance with manufacturer's written recommendations. Provide clean, dust-free, and dry substrate for waterproofing application.
- B. Mask off adjoining surfaces not receiving waterproofing to prevent spillage or overspray affecting other construction.
- C. Close off deck drains and other deck penetrations to prevent spillage and migration of waterproofing fluids.
- D. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, acid residues, and other penetrating contaminants or film-forming coatings from concrete.
 - 1. Abrasive blast clean concrete surfaces uniformly to expose top surface of fine aggregate in accordance with ASTM D 4259 with a self-contained, recirculating, blast-cleaning apparatus. Remove material to provide a sound surface free of laitance, glaze, efflorescence, curing compounds, concrete hardeners, or form-release agents. Remove remaining loose material and clean surfaces in accordance with ASTM D 4258.
- E. Remove fins, ridges, and other projections and fill honeycomb, aggregate pockets, and other voids.

3.4 PREPARATION AT TERMINATIONS AND PENETRATIONS

- A. Prepare vertical and horizontal surfaces at terminations and penetrations through waterproofing and at expansion joints, drains, and sleeves in accordance with ASTM C 898 and ASTM C 1471 and manufacturer's written instructions.
- B. Prime substrate unless otherwise instructed by waterproofing manufacturer.
- C. Apply waterproofing in two separate applications, and embed a joint reinforcing strip in the first preparation coat when recommended by waterproofing manufacturer.

1. Provide sealant cants around penetrations and at inside corners of deck-to-wall butt joints when recommended by waterproofing manufacturer.

3.5 JOINT AND CRACK TREATMENT

- A. Prepare, treat, rout, and fill joints and cracks in substrate in accordance with ASTM C 898 and ASTM C 1471 and waterproofing manufacturer's written instructions. Remove dust and dirt from joints and cracks, complying with ASTM D 4258, before coating surfaces.
 1. Comply with ASTM C 1193 for joint-sealant installation.
 2. Apply bond breaker between sealant and preparation strip.
 3. Prime substrate and apply a single thickness of preparation strip extending a minimum of 3 inches (75 mm) along each side of joint. Apply waterproofing in two separate applications and embed a joint reinforcing strip in the first preparation coat.
- B. Install sheet flashing and bond to deck and wall substrates where indicated or required in accordance with waterproofing manufacturer's written instructions.
 1. Extend sheet flashings onto perpendicular surfaces and other work penetrating substrate in accordance with ASTM C 898.

3.6 WATERPROOFING APPLICATION

- A. Apply waterproofing in accordance with ASTM C 898 and ASTM C 1471 and manufacturer's written instructions.
- B. Start installing waterproofing in presence of manufacturer's technical representative.
- C. Apply primer over prepared substrate.
- D. Installation of Modified Asphalt Waterproofing: Each ply shall consist of a 55 mil thick sheet set in adhesive.
 1. Mud Mats:
 - a. Two plies.
 - b. Waterproofing on a mud mat requires a layer of Laurencio adhesive dusted with cement applied to the second ply prior to construction traffic and placement of topping slab.
 2. Vertical Walls:
 - a. Intermediate waterheads to 50 feet: one ply.
 - b. Water heads 50 to 100 feet: two plies.
 - c. Water heads of 100 feet or more: three plies.
 3. Earth Retention System:
 - a. Water heads to 50 feet: two plies using the second ply as a protection course.
 - b. Water heads 50 to 100 feet: three plies using the third ply as a protection course.
 - c. Water heads of 100 feet or more: four plies using the forth ply as a protection course.
- E. Expansion Joint: Install appropriate proprietary expansion joint per manufacturer's instructions at locations shown.
- F. Install protection course with butted joints over nominally cured membrane before starting subsequent construction operations.

1. Board insulation may be used in place of a separate protection course to vertical applications when approved by waterproofing manufacturer.

3.7 MOLDED-SHEET DRAINAGE PANEL INSTALLATION

- A. Place and secure molded-sheet drainage panels, with geotextile facing away from wall or deck substrate, in accordance with manufacturer's written instructions. Do not penetrate waterproofing with fasteners. Lap edges and ends of geotextile fabric to maintain continuity. Protect installed molded-sheet drainage panels during subsequent construction.
 1. For vertical applications, install protection course and board insulation before installing drainage panels.

3.8 INSULATION INSTALLATION

- A. Install one or more layers of board insulation to achieve required thickness over waterproofed surfaces. Cut and fit to within 3/4 inch (19 mm) of projections and penetrations.
- B. On waterproofing surfaces, set insulation units into adhesive in accordance with manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

3.9 FIELD QUALITY CONTROL

- A. Site Representative: Engage a full time site representative qualified by the waterproofing membrane manufacturer to inspect substrate conditions, surface preparation, and application of the membrane, flashings, protection, and drainage components, and to furnish daily reports to Architect.
 1. Site representative shall measure membrane thickness with pin tester or other suitable device at least once for every 100 sq. ft. (10 sq. m) and include measurements in reports.
- B. Testing Agency: Engage a qualified testing agency to inspect substrate conditions, surface preparation, waterproofing application, protection, and drainage components, and to furnish reports to Architect.
- C. Post Installation Testing: All waterproofed surfaces.
 1. Flood Testing: Flood test each deck area for leaks, in accordance with recommendations in ASTM D 5957, after completing waterproofing but before overlaying construction is placed. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
 - a. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of sheet flashings.
 - b. Flood each area for 48 hours.
 - c. After flood testing, repair leaks, repeat flood tests, and make further repairs until waterproofing installation is watertight.
 2. Electric Field Vector Mapping (EFVM): EFVM technician shall survey entire waterproofing area for potential leaks using EFVM.
 - a. Install a permanent leak detection system by one of the following or approved equal:
 - 1) International Leak Detection, Ltd, Ontario, Canada
 - 2) Honza Group Incorporated, Columbia, Maryland

- b. Engage a company experienced in detecting breaches in the waterproofing using an electronic detection system.
 - c. If breaches are discovered, repair the breach and retest the affected area. Repeat this process until no breach is detected.
 3. Engage an independent testing agency to observe testing. If breaches are discovered, the independent testing agency shall observe repairs and retesting of discovered breaches.
 - D. Post Installation Testing of Penetrations, Drains, and, Horizontal Expansion Joints.
 1. Flood test each horizontal expansion joint, in accordance with recommendations in ASTM D 5957, after installation of the expansion joint but before overlaying construction is placed. Install temporary containment assemblies, plug or dam drains as required, and flood with potable water.
 2. Flood to an average depth of 2-1/2 inches (64 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm). Maintain 2 inches (50 mm) of clearance from top of sheet flashings.
 3. Flood each area for 48 hours.
 4. After flood testing, repair leaks, repeat flood tests, and make further repairs until expansion joint installation is watertight.
 5. Provided test reports upon completion of flood testing.
- 3.10 CURING, PROTECTION, AND CLEANING
- A. Cure waterproofing in accordance with manufacturer's written recommendations, taking care to prevent contamination and damage during application stages and curing.
 1. Do not permit foot or vehicular traffic on unprotected membrane.
 - B. Protect waterproofing from damage and wear during remainder of construction period.
 - C. Protect installed board insulation from damage due to ultraviolet light, harmful weather exposures, physical abuse, and other causes. Immediately after installation, provide temporary coverings where insulation will be subject to abuse and cannot be concealed and protected by permanent construction.
 - D. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION

SECTION 07 2100 - THERMAL INSULATION**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Extruded polystyrene foam-plastic board insulation.
 - 2. Mineral-wool board insulation.
 - 3. Glass-fiber blanket insulation.
 - 4. Mineral-wool blanket insulation.
 - 5. Loose-fill insulation.
- B. Related Requirements:
 - 1. Section 04 2200 "Concrete Unit Masonry" for insulation installed in masonry cells.
 - 2. Section 06 1600 "Sheathing" for foam-plastic board sheathing over wood or steel framing.
 - 3. Section 07 1416 "Cold Fluid-Applied Waterproofing" for insulated drainage panels installed with waterproofing.
 - 4. Section 07 2726 "Fluid-Applied Membrane Air Barriers for air and water barriers specified as a part of these systems.
 - 5. Section 07 8443 "Joint Firestopping" for insulation installed as part of a perimeter fire-resistive joint system.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 3. Laboratory Test Reports: For insulation, indicating compliance with requirements for low-emitting materials.
- C. Fire Test Reports: Provide NFPA 285 assembly test report.

1.3 INFORMATIONAL SUBMITTALS

- A. Installer's Certification: Listing type, manufacturer, and R-value of insulation installed in each element of the building thermal envelope.
 - 1. For blown-in or sprayed fiberglass and cellulosic-fiber loose-fill insulation, indicate initial installed thickness, settled thickness, settled R-value, installed density, coverage area, and number of bags installed.
 - 2. Sign, date, and post the certification in a conspicuous location on Project site.
- B. Product Test Reports: For each product, for tests performed by a qualified testing agency.
- C. Research Reports: For foam-plastic insulation, from ICC-ES.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials to the Project site in their original containers or packages or bundles bearing label clearly identifying manufacturer's name, brand, grade, UL listing, and other pertinent information.
- B. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.
- C. Protect foam-plastic board insulation as follows:
 - 1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
 - 2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site before installation time.
 - 3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 - PRODUCTS

2.1 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD INSULATION

- A. Type XPS-1: Extruded-Polystyrene Board Insulation: ASTM C 578, of type and minimum compressive strength indicated below; thickness and width indicated and manufacturer's standard length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E 84 manufactured with non-halogenated fire-retardants.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. DiversiFoam Products.
 - b. DuPont.
 - c. Owens Corning.
 - 2. Thermal Resistance: As indicated on drawings.
 - 3. Type X, 15 psi (104 kPa).
 - 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
- B. Type XPS-3: Geotextile-Faced Wall Insulation Drainage Panels: Extruded-polystyrene board insulation complying with ASTM C 578, Type IV, 25-psi (173-kPa) or Type VI, 40-psi (276-kPa) minimum compressive strength; fabricated with tongue-and-groove edges and with one side having grooved drainage channels faced with nonwoven geotextile filter fabric; thickness and width indicated and manufacturer's standard length as required to suit job conditions manufactured with non-halogenated fire-retardants.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Owens Corning.
 - 2. Thermal Resistance: Of total thickness required to provide a minimum thermal resistance of R-4.4 (deg. F.h.sf/Btu).

3. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

2.2 MINERAL-WOOL BOARD INSULATION

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Johns Manville.
 2. Owens Corning; Thermafiber.
 3. ROCKWOOL (formerly Roxul).
- B. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 16.5 mcg/cu. m or 13.5 ppb, whichever is less, except for insulation manufactured without formaldehyde.
- D. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- E. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- F. Type MW-1: Unfaced, Mineral-Wool Board Insulation: ASTM C 612; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 15 and zero, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
 1. Nominal density of 4 lb/cu. ft. (64 kg/cu. m), Types IA and IB, thermal resistivity of 4 deg F x h x sq. ft./Btu x in. at 75 deg F (27.7 K x m/W at 24 deg C).
 2. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
- G. Type MW-3: Unfaced, Mineral-Wool Rain Screen/Cavity Wall Insulation: ASTM C 612; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of zero and zero, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics. Required for use in exterior rain screen/cavity wall applications.
 1. Products: Subject to compliance with requirements, provide products by one of the following:
 - a. Owens Corning Thermafiber; , RainBarrier Dark.
 - b. ROCKWOOL.; CavityRock Black.
 - c. Johns Manville; Cladstone 60.
 2. Thermal Resistance: Of total thickness required to provide a minimum thermal resistance of R-30 (deg. F.h.sf/Btu).
 3. Facer Color: Darkened, where indicated.

4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

2.3 GLASS-FIBER BLANKET INSULATION

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. CertainTeed Corporation.
 2. Johns Manville.
 3. Owens Corning.
- B. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent
- D. Type FG-9: Unfaced, Glass-Fiber Blanket Insulation: ASTM C 665, Type I; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
 1. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

2.4 MINERAL-WOOL BLANKET INSULATION

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Johns Manville.
 2. Owens Corning - Thermafiber (Basis of Design).
 3. Rockwool International.
- B. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- D. Type MW-1: Unfaced, Mineral-Wool Blanket Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville.
 - b. Owens Corning - ThermaFiber RainBarrier (Basis of Design).
 - c. Rockwool International.

2. Minimum thermal resistivity (R) of 3.1deg F x h x sq. ft./Btu x in. (21.7 K x m/W) at mean temperature of 75 degrees F (24 degrees C).
 3. Thermal Resistance: Of total thickness indicated required to provide a minimum thermal resistance of R-10 insert value (deg. F.h.sf/Btu).
 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.
- E. Type MW-2: Unfaced, Mineral-Wool Blanket Insulation: ASTM C 665, Type I (blankets without membrane facing); consisting of fibers; thickness as indicated with width and length as required to suit job conditions; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively, per ASTM E 84; passing ASTM E 136 for combustion characteristics.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville.
 - b. Owens Corning - ThermaFiber Fire & Sound Guard Plus (Basis of Design).
 - c. Rockwool International.
 2. Minimum density of 4.0 lbs. per cubic foot (16 kg per cubic meter).
 3. Minimum thermal resistivity (R) of 3.1deg F x h x sq. ft./Btu x in. (21.7 K x m/W) at mean temperature of 75 degrees F (24 degrees C).
 4. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

2.5 LOOSE-FILL INSULATION

- A. Insulation shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- C. Cellulosic-Fiber Loose-Fill Insulation: ASTM C 739, chemically treated for flame-resistance, processing, and handling characteristics.
 1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than Insert number percent.
 2. Thermal Resistance: As indicated on drawings.

2.6 INSULATION FASTENERS

- A. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of specified thickness securely in position indicated with self-locking washer in place.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Gemco; 90-Degree Insulation Hangers.
 2. Angle: Formed from 0.030-inch- (0.762-mm-) thick, perforated, galvanized carbon-steel sheet with each leg 2 inches (50 mm) square.
 3. Spindle: Copper-coated, low-carbon steel; fully annealed; 0.105 inch (2.67 mm) in diameter; length to suit depth of insulation indicated.

- B. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized-steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. AGM Industries, Inc.; RC150.
 - b. Gemco; R-150.
- C. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates indicated without damaging insulation, air barrier, fasteners, and substrates. When in contact with air barrier, provide adhesive and chemical compatible material that is acceptable by the air barrier manufacturer.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. AGM Industries, Inc.
 - b. Gemco.
 - 2. Adhesion Strength: 15 lbf/sq. in. (207 kPa) minimum.

2.7 ACCESSORIES

- A. Insulation for Miscellaneous Voids:
 - 1. Glass-Fiber Insulation: ASTM C764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E84.
 - 2. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.

END OF SECTION

SECTION 07 2600 - VAPOR RETARDERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Polyethylene vapor retarders.
 - 2. Reinforced-polyethylene vapor retarders.
 - 3. Fire-retardant, reinforced-polyethylene vapor retarders.
- B. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for under-slab vapor retarders.
 - 2. Section 07 2100 "Thermal Insulation" for vapor retarders integral with insulation products.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.3 QUALITY ASSURANCE

- A. Provide the following upon request:
 - 1. Product Test Reports: For each product, for tests performed by a qualified testing agency.

PART 2 - PRODUCTS

2.1 POLYETHYLENE VAPOR RETARDERS

- A. Type VR-1: Polyethylene Vapor Retarders: ASTM D 4397, 10-mil- (0.25-mm-) thick sheet, with maximum permeance rating of 0.1 perm (5.7 ng/Pa x s x sq. m).

2.2 REINFORCED-POLYETHYLENE VAPOR RETARDERS

- A. Type VR-2: Reinforced-Polyethylene Vapor Retarders: Sheet with outer layers of polyethylene film laminated to an inner reinforcing layer consisting of either nylon cord or polyester scrim and weighing not less than 20 lb/1000 sq. ft. (9 kg/100 sq. m), with maximum permeance rating of 0.1 perm (5.7 ng/Pa x s x sq. m).
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Insulation Solutions, Inc.
 - b. Raven Industries Inc.
 - c. Reef Industries, Inc.

2.3 FIRE-RETARDANT, REINFORCED-POLYETHYLENE VAPOR RETARDERS

- A. Type VR-3: Fire-Retardant, Reinforced-Polyethylene Vapor Retarders: Sheet with outer layers of polyethylene film laminated to an inner reinforcing layer consisting of either nonwoven grid of nylon cord or polyester scrim and weighing not less than 20 lb/1000 sq. ft. (9 kg/100 sq. m), with maximum permeance rating of 0.1 perm (5.7 ng/Pa x s x sq. m).
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Raven Industries Inc.
 - b. Reef Industries, Inc.
 - 2. Surface-Burning Characteristics: Maximum flame-spread and smoke-developed indexes of 75 and 200, respectively, per ASTM E 84.

2.4 ACCESSORIES

- A. Vapor-Retarder Tape: Pressure-sensitive tape of type recommended by vapor-retarder manufacturer for sealing joints and penetrations in vapor retarder.
- B. Adhesive for Vapor Retarders: Product recommended by vapor-retarder manufacturer and has demonstrated capability to bond vapor retarders securely to substrates indicated.
- C. Vapor-Retarder Fasteners: Pancake-head, self-tapping steel drill screws; with fender washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean substrates of substances that are harmful to vapor retarders, including removing projections capable of puncturing vapor retarders.

3.2 INSTALLATION OF VAPOR RETARDERS ON FRAMING

- A. Place vapor retarders on side of construction indicated on Drawings.
- B. Extend vapor retarders to extremities of areas to protect from vapor transmission. Secure vapor retarders in place with adhesives, vapor retarder fasteners, or other anchorage system as recommended by manufacturer. Extend vapor retarders to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.
- C. Seal vertical joints in vapor retarders over framing by lapping no fewer than two studs and sealing with vapor-retarder tape in accordance with vapor-retarder manufacturer's written instructions. Locate all joints over framing members or other solid substrates.
- D. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarders.
- E. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarders.

3.3 INSTALLATION OF VAPOR RETARDERS IN CRAWL SPACES

- A. Install vapor retarders over prepared grade. Lap joints a minimum of 12 inches (305 mm) and seal with manufacturer's recommended tape. Install second layer over pathways to equipment.
- B. Extend vapor retarder over footings and seal to foundation wall or grade beam with manufacturer's recommended tape.
 - 1. Extend vapor retarder vertically minimum 24 inches (610 mm) above top of footing.
- C. Seal around penetrations such as utilities and columns in order to create a monolithic, airtight membrane at grade surface, perimeter, and all vertical penetrations.

3.4 PROTECTION

- A. Protect vapor retarders from damage until concealed by permanent construction.

END OF SECTION

FOR REFERENCE ONLY

SECTION 07 2726 - FLUID-APPLIED MEMBRANE AIR BARRIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes fluid-applied, and vapor-permeable membrane air barriers, that incorporates the ABAA Quality Assurance Program (QAP).
- B. Related Requirements:
 - 1. Section 06 1600 "Sheathing" for wall sheathings and wall sheathing joint-and-penetration treatments.

1.2 DEFINITIONS

- A. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air.
- B. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.
- C. Air-Barrier Assembly: The collection of air-barrier materials and accessory materials applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Include installers of other construction connecting to air barrier, including roofing, waterproofing, masonry, sealants.
 - 2. Review air barrier requirements including surface preparation, substrate condition and pretreatment, minimum substrate curing period, forecasted weather conditions, special details and sheet flashings, mockups, installation procedures, sequence of installation, testing and inspecting procedures, materials approved for use, compatibility of materials, coordination with installation of adjacent and covering materials, and protection and repairs.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include manufacturer's written instructions for evaluating, preparing, and treating substrate; technical data; and tested physical and performance properties of air barrier.
 - 1. Include manufacturer's written instructions for evaluating, preparing, and treating substrate; technical data; and tested physical and performance properties of products.
 - 2. Submit letter from primary materials manufacturer indicating approval of products not manufactured by primary manufacturer.
 - 3. Include statement that materials are compatible with adjacent materials proposed for use and the following.
 - a. For materials that the air barrier system will bond to, provide letters as necessary from each manufacturer confirming materials and substrates for the air barrier system is chemically and adhesively compatible with the air barrier system and the bonded to material.

- b. For materials that are proposed to bond to the air barrier system, provide letters as necessary from each manufacturer confirming materials proposed to bond to the air barrier system are chemically and adhesively compatible with the air barrier system.
 4. Submit reports indicating that field peel-adhesion test on all materials to which sealants are adhered have been performed and the changes made, if required, to other approved materials, in order to achieve successful adhesion.
- B. Shop Drawings: For air-barrier assemblies.
 1. Show locations and extent of air barrier. Include project specific details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.
 2. Indicate total area (sq. ft.) of air barrier to be installed.
 3. Include project specific details of interfaces with other materials that form part of the air barrier.
 4. Include letter from manufacturer indicating that the project specific details and shop drawings have been reviewed and are approved for use.
- C. Samples: Submit clearly labeled samples, 3 by 4 inch (75 mm by 100 mm) minimum size of each material specified.
- D. Field Test Results: Submit mockup and in-situ test results of air leakage test and water leakage test with specified standards, including retesting if initial results are not satisfactory.
- E. Qualification Data: For Installer. Include list of ABAA-certified installers and supervisors employed by the Installer, who work on Project.
 1. Provide evidence from the manufacturer that the firm is approved, authorized, or licensed to install the specified products and is eligible to receive manufacturer's special warranty.
 2. Provide evidence that the installing firm is experienced in applying air barrier materials similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.
 3. Provide a manual that describes Installers and Manufacturers Quality Assurance / Quality Control program and procedures.
 4. Sample of Installers Daily Work Sheet.
 5. Submit evidence of current accreditation and certification under the Air Barrier Association of America's (ABAA) Quality Assurance Program. Submit accreditation number of manufacturer and certification number of installers.
- F. Product Certificates: From air-barrier manufacturer, certifying permanent chemical and adhesive compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier, and certifying that cleaning materials used during installation are chemically compatible with each of the adjacent materials proposed for use.
- G. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.
- H. Fire Test Reports: Provide NFPA 285 assembly test report.
- I. Sample Warranty: Manufacturer and Installer sample warranty.

- J. ABAA Audit Schedule: Submit number of ABAA audits planned based on the QAP requirements and total area of installed air barrier. Indicate anticipated timeframe of audits.
- K. Installation Reports: Provide ABAA Audit Reports and Installer Daily Worksheet for project record. Provide reports weekly to Architect for each week installation of air barrier system occurs.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:

- 1. A qualified firm that is approved, authorized, or licensed by the manufacturer to install manufacturer's product, that is eligible to receive manufacturer's special warranty, and is experienced in applying air barrier materials similar in material, design, and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.
- 2. A firm that is an ABAA-licensed contractor and employs certified and registered installers.
- 3. A firm that complies with ABAA's Quality Assurance Program.
- 4. Installer shall be licensed by ABAA according to ABAA's Quality Assurance Program and shall employ ABAA-certified installers and supervisors on Project.

B. Manufacturer Qualifications: A qualified manufacturer regularly engaged in manufacturing air barrier membranes.

C. Quality Assurance / Quality Control Program:

- 1. Implement the ABAA Quality Assurance Program requirements. Cooperate with ABAA inspectors and independent testing and inspection agencies engaged by the Owner. Do not cover air barrier until it has been inspected, tested and accepted.
- 2. Notify Architect seven days in advance of the dates and times when ABAA Audits are performed.
- 3. Daily Inspection:
 - a. Visual inspection of the substrate prior to the application of membrane to confirm the substrate is in accordance with the manufacturer's instructions.
 - b. Visual inspection on the completed air barrier for that day and fix any deficiencies.
 - c. Verification of manufactures specific Wet film thickness of installed work.
 - d. Adhesion Test as indicated in Field Quality Control.
- 4. Daily Work Sheet: Include requirements of the ABAA QAP and the following:
 - a. Listing of installers
 - b. Project name
 - c. Type of air barrier installed
 - d. Air barrier product name and lot/batch number
 - e. Primer product name and lot/batch number
 - f. Substrate type
 - g. Substrate preparation required
 - h. Installation locations (gridlines, elevations, etc)
 - i. Results of visual inspection
 - j. Results of verification of wet film thickness, include photo documentation
 - k. Results of verification of adhesion testing, include photo documentation
 - l. Document and photograph observed deficiencies and corrective actions preformed
 - m. Date and Time of installation

- n. Substrate moisture content
- o. Weather Conditions including but not limited to ambient temperature, relative humidity, and precipitation.
- 5. Testing, Inspection, and Reporting as indicated in the Field Quality control.
- D. Mockups: Before beginning installation of air barrier, build mockups to set quality standards for materials and execution and for preconstruction testing.
 - 1. Build mockups of exterior wall assembly as shown on Drawings, incorporating backup wall construction, external cladding, window, storefront, door frame and sill, insulation, ties and other penetrations, and flashing to demonstrate surface preparation, crack and joint treatment, application of air barriers, and sealing of gaps, terminations, and penetrations of air-barrier assembly.
 - a. Coordinate construction of mockups to permit inspection by Owner's testing agency of air barrier before external insulation and cladding are installed.
 - b. Include junction with roofing vapor retarder, building corner condition, and below-grade waterproofing where applicable.
 - c. If Architect determines mockups do not comply with requirements, reconstruct mockups and apply air barrier until mockups are approved.
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Owner will engage a qualified testing agency to perform preconstruction testing on field mockups.
- B. Mockup Testing: Air-barrier assemblies shall comply with performance requirements indicated, as evidenced by reports based on mockup testing by a qualified testing agency.
 - 1. Qualitative Air-Leakage Testing: Mockups will be tested for evidence of air leakage according to ASTM E 1186, chamber depressurization with detection liquids.
 - a. Test Locations: For each substrate type, provide three tests for each penetration type.
 - b. Test Pressure: 500 Pa.
 - c. Pass/Fail Criteria: Visual observation of air leakage evidenced by continuous foaming "bubbling" of detection liquid is considered a failed test.
 - d. Provide an inspection report that indicates results.
 - 2. Qualitative Air-Leakage-Location Testing: Air-barrier assemblies will be tested for evidence of air leakage according to ASTM E 1186, chamber pressurization or depressurization with smoke tracers.
 - a. Testing to be performed concurrent with Water Penetration Testing indicated below.
 - b. Testing to be performed after cladding attachment system is installed but prior to cladding installation.
 - c. Test Pressure: 6.24 lbf/sq.ft.
 - d. Failure Criteria: Visual evidence of air leakage by means of observations of smoke infiltration or exfiltration.
 - e. Provide an inspection report that indicates results.

3. Qualitative Water Infiltration Testing: Perform testing prior to installation of the cladding, but after cladding attachment systems have been installed. Air barrier systems shall be tested according to ASTM E 1105 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft., and shall not evidence water infiltration.
 - a. Test Locations: Perform one test for each wall assembly type.
 - b. Test Size: 100 sq. ft. minimum.
 - c. Perform tests after cladding attachments have been installed but prior to the installation of cladding/veneer material.
 - d. Water Infiltration Failure Criteria:
 - 1) Water leakage to the interior of the building is a failure.
 - 2) Water observed on interior surfaces of the system is a failure.
 - 3) Water observed on interior surfaces of adjacent systems, originating from the wall system or the transition to the adjacent systems, is a failure.
 - e. Provide an inspection report that indicates results.
4. Water Spray Test: Areas designated by the Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.
 - a. Perform tests at transitions to adjacent exterior enclosure assemblies, deflection joints, and expansion joints.
 - b. Perform tests at a representative sample of each condition.
 - c. Water Penetration Failure Criteria:
 - 1) Water leakage to the interior of the building is a failure.
 - 2) Water observed on interior surfaces of the system is a failure.
 - 3) Water observed on interior surfaces of adjacent systems, originating from the wall system or the transition to the adjacent systems, is a failure.
 - d. Provide an inspection report that indicates results.
5. Adhesion Testing: Mockups will be tested for minimum air-barrier adhesion of 16 lbf/sq. in. (207 kPa) or to manufacturer's minimum adhesion level per substrates, whichever is greater, according to ABAA T0002. Perform test after curing period recommended by the manufacturer. Record mode of failure and area which failed in accordance with referenced standard.
 - a. Test Locations: Perform 1 test per substrate type. (Each test site includes 3 pull tests)
 - b. Provide an inspection report that indicates results.
6. Wet Film Thickness Test (to be performed by installer at time of installation and included on ABAA QAP daily worksheet):
 - a. Test material using wet film gauge to confirm that membrane meets manufacturer's indicated wet film thickness requirements.
 - b. Minimum one per coat per substrate type.
 - c. Failure Criteria:
 - 1) A measurement less than manufacturer's required wet film thickness is considered a failure.
 - d. Provide an inspection report indicating results and include photo documentation.
7. Dry Film Thickness Test:
 - a. Test material in accordance with manufacturer's requirements to confirm that cured membrane meets manufacturer's indicated dry film thickness requirements.
 - b. Three 1 inch x 4 inch samples removed from separate areas with gypsum facer intact to avoid stretching membrane.
 - c. Failure Criteria:
 - 1) A measurement less than manufacturer's required dry film thickness is considered a failure.
 - d. Provide an inspection report indicating results and include photo documentation.

8. Air barriers will be considered defective if they do not pass tests and inspections.
 - a. Wet Film Thickness: Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
 - b. Upon failure of Dry Film Testing or Adhesion Testing:
 - 1) Determine cause of failure.
 - 2) Provide one additional test for each occurrence of failure on the mockup.
 - 3) Repair deficient air barrier components per manufacturer's recommendations.
 - 4) Repair tested areas per manufacturer's recommendations.
 - c. Upon failure of E1186 and E1105 testing:
 - 1) Determine cause of failure.
 - 2) Repair per manufacturer's recommendations and retest deficient air barrier components.
9. Notify Architect 14 days in advance of the dates and times when mockups will be tested.
10. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
11. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Remove and replace liquid materials that cannot be applied within their stated shelf life.
- B. Protect stored materials from direct sunlight.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended by air-barrier manufacturer.
 1. Protect substrates from environmental conditions that affect air-barrier performance.
 2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

1.9 WARRANTY

- A. Manufacturer's Warranty: Provide manufacturer's standard product warranty, for a minimum 10 years from date of Substantial Completion.
- B. Special Installer's Warranty: Provide air barrier installer's 2 year warranty from date of Substantial Completion, including all components of the air barrier assembly, against failures including loss of air tight seal, loss of watertight seal, loss of adhesion, loss of cohesion, failure to cure properly.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Source Limitations: Obtain primary ABAA evaluated materials and air-barrier accessories from single source ABAA evaluated manufacturer. Additional accessory products are acceptable for use provided they are approved by the primary air barrier manufacturer.

- B. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

2.2 PERFORMANCE REQUIREMENTS

- A. General: Air barrier shall be capable of performing as a continuous vapor-retarding permeable air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies shall be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, tie-ins to installed waterproofing, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.
- B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.2 L/s x sq. m of surface area at 75 Pa), when tested according to ASTM E 2357.
- C. Provide an air barrier assembly that withstands combined positive and negative design wind, fan and stack pressures on the envelope without damage or displacement, that transfers the load to the structure, and that does not displace adjacent materials under full load. Join air barrier system materials in an airtight and flexible manner to adjacent assemblies, allowing for the relative movement of assemblies due to thermal and moisture variations and creep, and anticipated seismic movement.

2.3 VAPOR-RETARDING MEMBRANE AIR BARRIER

- A. Fluid-Applied, Vapor-Retarding Membrane Air Barrier:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Carlisle Coating & Waterproofing; Fire Resist Barritech NP.
 - b. GCP, Applied Technologies; Perm-A-Barrier NPL.
 - c. Henry Company; Air-Bloc 16MR.
 2. Physical and Performance Properties:
 - a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75-Pa) pressure difference; ASTM E 2178.
 - b. Vapor Permeance: Maximum 0.1 perm; ASTM E 96/E 96M.
 - c. Ultimate Elongation: Minimum 300 percent; ASTM D 412, Die C.
 - d. Structural Test Performance: Test according to ASTM E 330 or ASTM E1233 at a positive or negative pressure of 30 psf.
 - 1) No cracking within the field of the panel, substrate joints and at interface of flashing.
 - e. Water Penetration under Static Pressure: No evidence of water penetration through the air barrier assembly when tested according to ASTM E 331 at a minimum static-air-pressure differential of 6.24 lbf/sq.ft.
 - 1) Water Penetration: Water leakage to the interior of the building is a failure. Water observed on interior surfaces of the system or adjacent wall systems is a failure.

2.4 VAPOR-PERMEABLE MEMBRANE AIR-BARRIER

- A. Fluid-Applied, Vapor-Permeable Membrane Air Barrier:
1. Silicone Based Technology Products: Subject to compliance with requirements, provide one of the following:
 - a. Dow Corning Corp.; Defend Air 200.

- b. Momentive Performance Materials; Elemax 2600 AWB.
- 2. STPE Based Technology Products: Subject to compliance with requirements, provide one of the following:
 - a. DuPont; Tyvek Fluid Applied WB +.
 - b. GCP, Applied Technologies; Perm-A-Barrier VPL 50 RS.
 - c. Prosoco; CAT 5.
- 3. Physical and Performance Properties:
 - a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75-Pa) pressure difference; ASTM E 2178.
 - b. Vapor Permeance: Minimum 10 perms (580 ng/Pa x s x sq. m); ASTM E 96/E 96M.
 - c. Ultimate Elongation: Minimum 200 percent; ASTM D 412, Die C.
 - d. Structural-Test Performance: Test according to ASTM E 330 or ASTM E1233 at a positive or negative pressure of 30psf.
 - 1) No cracking within the field of the panel, substrate joints and at interface of flashing.
 - e. Water Penetration under Static Pressure: No evidence of water penetration through the air barrier assembly when tested according to ASTM E 331 at a minimum static-air-pressure differential of 6.24 lbf/sq.ft..
 - 1) Water Penetration: Water leakage to the interior of the building is a failure. Water observed on interior surfaces of the system or adjacent wall systems is a failure.

2.5 ACCESSORY MATERIALS

- A. General: Accessory materials recommended by air-barrier manufacturer to produce a complete air-barrier assembly and compatible with primary air-barrier material.
- B. Transition Membrane: Between Air Barrier Membrane and Other Adjacent Materials: Comply with both air barrier manufacturer's recommendations and adjacent material manufacturer's recommendations.
 - 1. Fluid-Applied Flashing: Manufacturer's standard trowel grade liquid flashing.
 - a. Joint Reinforcing Strip: Air-barrier manufacturer's glass-fiber-mesh tape.
 - 2. High Temperature Modified Bituminous Strip: 40 mils (1.0 mm) thick, smooth surfaced, self-adhering; consisting of 36 mils (0.9 mm) of rubberized asphalt laminated to a 4-mil- (0.1-mm-) thick polyethylene film with release liner backing.
 - a. For use under metal copings and flashings directly exposed to the exterior.
 - 3. Foil Faced Modified Bituminous Strip: 40 mils (1.0 mm) thick, smooth surfaced, self-adhering; consisting of 36 mils (0.9 mm) of rubberized asphalt laminated to a 4-mil- (0.1-mm-) thick polyethylene film with release liner backing.
 - 4. Preformed Silicone-Sealant Extrusion: Manufacturer's standard system consisting of cured low-modulus silicone extrusion, sized to fit opening widths, with a single-component, neutral-curing, Class 100/50 (low-modulus) silicone sealant for bonding extrusions to substrates.
 - a. Dow Corning Corporation; Silicone Transition Strip System.
 - b. Momentive Performance Materials Inc.; US11000 UltraSpan.
 - c. Tremco Incorporated; Proglaze ETA Connections.
 - 5. Self-Adhering Stainless Steel Flexible Flashing:
 - a. Subject to compliance with requirements, provide the following:
 - 1) York Manufacturing Inc.; York 316.
 - b. Characteristics:

- 1) Type: Stainless steel with one stainless steel face (facing outwards) with a butyl block co-polymer adhesive (inward facing).
 - 2) Stainless Steel: Type 304 or 316, ASTM A240. Domestically sourced per DF ARS 252.225-7008 and/or DF ARS 252.225-7009.
- C. Primer: Liquid primer recommended for substrate by air-barrier material manufacturer.
- D. Substrate-Patching Membrane: Manufacturer's standard trowel-grade substrate filler.
- E. Adhesive and Tape: Air-barrier manufacturer's standard adhesive and pressure-sensitive adhesive tape.
- F. Stainless-Steel Sheet: ASTM A 240/A 240M, Type 304, 0.0187 inch (0.5 mm) thick, and Series 300 stainless-steel fasteners.
- G. Sprayed Polyurethane Foam Sealant: One- or two-component, foamed-in-place, polyurethane foam sealant, 1.5- to 2.0-lb/cu. ft (24- to 32-kg/cu. m) density; flame-spread index of 25 or less according to ASTM E 162; with primer and noncorrosive substrate cleaner recommended by foam sealant manufacturer.
- H. Joint Sealant: ASTM C 920, single-component, neutral-curing silicone; Class 100/50 (low modulus), Grade NS, Use NT related to exposure, and, as applicable to joint substrates indicated, Use O. Comply with Section 07 9200 "Joint Sealants."
- I. CMU Block Filler: Manufacturer's standard filler.
- J. Concrete Filler: Manufacturer's standard filler.
- K. Termination Mastic: Air-barrier manufacturer's standard cold fluid-applied elastomeric liquid; trowel grade.
- L. Metal Termination Bars: Manufacturer's standard, predrilled stainless-steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchor spacing of 9" on center minimum unless otherwise required by the manufacturer. Provide galvanized sheet metal backup plate at locations where adequate substrate is not available for securing the termination bar.
- M. Provide galvanized sheet metal backup plate at locations where adequate substrate is not available for securing the cladding accessories and attachments, flashings, and termination bars.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
 2. Provide verification in writing from the air-barrier manufacturer that concrete has cured and aged for minimum time period required by air-barrier manufacturer.
 3. Verify that concrete is visibly dry and free of moisture.

4. Perform moisture testing as required by air-barrier manufacturer for test type, rate, and quantity to validate that substrate is acceptable, dry, and free of moisture.
5. Verify that the minimum concrete drying period recommended by air barrier system manufacturer has passed. Perform moisture content testing as required by the air barrier system manufacturer to verify concrete is acceptable for installation of air barrier.
6. Verify that masonry joints are flush and completely filled with mortar.
7. Verify sealants used in sheathing are compatible with membrane proposed for use. Perform field peel-adhesion test on materials to which sealants are adhered.
8. Verify that metal strapping has been installed where required for securing accessories such as termination bars and flashings.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SURFACE PREPARATION

- A. Clean, prepare, treat, and seal substrate according to manufacturer's written instructions. Provide clean, dust-free, and dry substrate for air-barrier application.
- B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.
- C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.
- D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching membrane.
- E. Remove excess mortar from masonry ties, shelf angles, and other obstructions.
- F. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.
- G. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless-steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.

3.3 JOINT TREATMENT

- A. Concrete and Masonry: Prepare, treat, rout, and fill joints and cracks in substrate according to ASTM C 1193 and air-barrier manufacturer's written instructions. Remove dust and dirt from joints and cracks complying with ASTM D 4258 before coating surfaces.
 1. Prime substrate and apply air-barrier manufacturer's recommended thickness, number of coats, and reinforcement extending a minimum of 3 inches (75 mm) along each side of joints and cracks. Apply a double thickness of fluid air-barrier material and embed a joint reinforcing strip in preparation coat.
- B. Gypsum Sheathing: Fill joints greater than 1/4 inch (6 mm) with sealant according to ASTM C 1193 and air-barrier manufacturer's written instructions. Apply first layer of fluid air-barrier material at joints. Tape joints with joint reinforcing strip after first layer is dry. Apply a second layer of fluid air-barrier material over joint reinforcing strip.

3.4 TRANSITION MEMBRANE INSTALLATION

- A. General: Install transition membrane and accessory materials according to air-barrier manufacturer's written instructions to form a seal with adjacent construction and maintain a continuous air barrier.
 - 1. Coordinate the installation of air barrier with installation of roofing membrane, below grade waterproofing, and base flashing to ensure continuity of air barrier with roofing membrane.
 - 2. Install manufacturer's recommended transition strip on roofing membrane or base flashing so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate.
- B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.
 - 1. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats needed to achieve required bond, with adequate drying time between coats.
- C. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials as recommended by manufacturer.
- D. At end of each working day, seal top edge of transition membrane to substrate with termination mastic.
- E. Apply joint sealants forming part of air-barrier assembly within manufacturer's recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.
- F. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition membrane so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate. Maintain 3 inches (75 mm) of full contact over firm bearing surface.
 - 1. Provide fluid-applied membranes for manufacturer's that offer it as part of the air barrier system.
 - 2. For manufacturers that do not offer a liquid flashing, use transition membrane method that is acceptable to the air barrier manufacturer and that is chemically and adhesively compatible with the adjacent construction.
 - a. Self-Adhering Stainless Steel Flexible Flashing Transition Strip: Roll firmly to enhance adhesion.
 - b. Preformed Silicone-Sealant Extrusion: Set in full bed of silicone sealant applied to walls, frame, and air-barrier material. Tool sealant along edges of extrusion.
- G. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier material with foam sealant.
- H. Seal transition membrane around masonry reinforcing or ties and penetrations with termination mastic.

- I. Seal top of through-wall flashings to air barrier with an additional 6-inch- (150-mm-) wide, transition membrane.
- J. Seal exposed edges of transition membrane at seams, cuts, penetrations, and terminations not concealed by metal counterflashings or ending in reglets with termination mastic.
- K. Repair punctures, voids, and deficient lapped seams in transition membrane. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches (150 mm) beyond repaired areas in strip direction.

3.5 FLUID AIR-BARRIER MEMBRANE INSTALLATION

- A. General: Apply fluid air-barrier material to form a seal with transition membrane and to achieve a continuous air barrier according to air-barrier manufacturer's written instructions. Apply fluid air-barrier material within manufacturer's recommended application temperature ranges.
 - 1. Apply primer to substrates at required rate and allow it to dry.
 - 2. Limit priming to areas that will be covered by fluid air-barrier material on same day. Reprime areas exposed for more than 24 hours.
 - 3. Prime glass-fiber-surfaced gypsum sheathing with number of prime coats as recommended by the manufacturer and as needed to achieve required bond, with adequate drying time between coats.
- B. Membrane Air Barriers: Apply a continuous unbroken air-barrier membrane to substrates according to the following thickness. Apply air-barrier membrane in full contact around protrusions such as masonry ties.
 - 1. Apply to a total wet film thickness as required by the membrane manufacturer to meet the performance requirements indicated.
- C. Apply transition membrane according to air-barrier manufacturer's written instructions.
- D. Provide air barrier and accessories that are acceptable for use at horizontal surfaces without detrimental effects to material.
- E. For exterior cladding and veneer attachment devices and accessories such as clips, thermal breaks, brick ties, flashings, stone/metal coping fasteners, and metal panel anchors:
 - 1. Set device in a full bed of sealant after air barrier is cured.
 - 2. Seal over fastener heads after device is secured.
 - 3. Seal top edge of accessories installed in the horizontal orientation.
- F. Do not cover air barrier until it has been tested and inspected by Owner's testing agency.
- G. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

- B. Owner's Inspection and Testing/ABAA Audits: Cooperate with Owner's testing agency and ABAA auditors. Allow access to work areas and staging. Notify Owner's testing agency/ABAA auditor in writing of schedule for Work of this Section to allow sufficient time for testing and inspection. Daily inspection and testing may be required. Do not cover Work of this Section until testing and inspection is accepted.
- C. Periodic Inspections: Provide for air barrier system manufacturer's technical personnel to inspect installation weekly during periods of ongoing installation.
- D. Inspections: Air-barrier materials, accessories, and installation are subject to inspection for compliance with requirements. Inspections may include the following:
1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
 2. Air-barrier dry film thickness.
 3. Air-barrier wet film thickness (to be performed by installer at time of installation and included on ABAA QAP daily worksheet).
 4. Continuous structural support of air-barrier system has been provided.
 5. Masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions, and mortar droppings.
 6. Site conditions for application temperature and dryness of substrates have been maintained.
 7. Maximum exposure time of materials to UV deterioration has not been exceeded.
 8. Surfaces have been primed, if applicable.
 9. Laps in transition membranes have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.
 10. Termination mastic has been applied on cut edges.
 11. Transition membranes are firmly adhered to substrate.
 12. Compatible materials have been used.
 13. Transitions at changes in direction and structural support at gaps have been provided.
 14. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
 15. All penetrations have been sealed.
- E. Field Tests:
1. Allow sufficient time for testing and inspection and provide a schedule in advance to the Testing Agency.
 2. Whenever Work is to be done, notify Testing Agency in sufficient time to provide inspections.
 3. Provide to the Owner copies of Quality Assurance Program documentation including daily site reports completed by installers.
 4. Submit test results in accordance with specified standards, including retesting if initial results are not satisfactory.
 5. Test to be distributed uniformly across all elevations.

6. Membrane Adhesion Test: Test materials for a minimum air-barrier adhesion of 16 lbf/sq. in. or to manufacturer's minimum adhesion level per substrates, whichever is greater in accordance with ABAA T0002. Perform test after curing period recommended by the manufacturer. Record mode of failure and area which failed in accordance with referenced standard. To be performed by installer and included on ABAA QAP daily worksheet.
 - a. Test Site Locations: Perform 1 test once daily per substrate during installation and a minimum of 4 test sites per major elevation per substrate. (Each test site includes 3 pull tests).
 - 1) Perform one test for the first 2500 sq. ft. of installed material for each wall assembly type.
 - b. Provide an inspection report in accordance with referenced standard that indicates whether or not the air barrier material has met the minimum adhesion level requirement and include photo documentation.
 - c. Provide reports within 3 days of test completion.
7. Qualitative Air-Leakage-Location Testing: Air-barrier assemblies will be tested for evidence of air leakage according to ASTM E 1186, chamber depressurization using detection liquids.
 - a. Test Locations: Provide ten tests for each penetration type per 2500 sq. ft. of each substrate. Distribute test locations across all elevations.
 - b. Test Pressure: 500 Pa.
 - c. Pass/Fail Criteria: Visual observation of air leakage evidenced by continuous foaming "bubbling" of detection liquid is considered a failed test.
 - d. Provide an inspection report that indicates results and include photo documentation.
8. Qualitative Air-Leakage-Location Testing: Air-barrier assemblies will be tested for evidence of air leakage according to ASTM E 1186, chamber pressurization or depressurization with smoke tracers.
 - a. Testing to be performed concurrent with Qualitative Water Infiltration Testing below.
 - b. Pass/Fail Criteria: Visual observation of air leakage evidenced by smoke tracer penetrating air barrier system is considered a failed test.
 - c. Provide an inspection report that indicates results, including photos.
9. Qualitative Water Infiltration Testing: Perform testing prior to installation of the cladding, but after cladding attachment systems have been installed. Air barrier systems shall be tested according to ASTM E 1105 at a minimum static-air-pressure differential of 6.24 lbf/sq. ft., and shall not evidence water infiltration.
 - a. Test Locations:
 - 1) Perform one test for the first 2500 sq. ft. of installed material for each wall assembly type.
 - 2) Perform one subsequent test for every 5000 sq. ft. of installed material for each wall assembly type.
 - 3) Test locations to be selected by Architect.
 - b. Test Size: 100 sq. ft. minimum.
 - c. Perform tests after cladding attachments have been installed but prior to the installation of cladding/veneer material.
 - d. Pass/Fail Criteria:
 - 1) Water infiltration/leakage to the interior of the building which is not controlled by a weep/drainage system that is integral to the system is a failure.
 - 2) Water observed on interior surfaces of the systems is a failure.

- 3) Water observed on interior surfaces of the adjacent systems, originating from the wall system or the transition to the adjacent systems, is a failure.
- e. Provide an inspection report that indicates results and include photo documentation.
10. Water Spray Test: Before installation of interior finishes has begun, areas designated by the Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.
 - a. Perform tests at transitions to adjacent wall assemblies, control joints, deflection joints, and expansion joints.
 - b. Test 250 linear feet of all joint locations.
 - c. Water Infiltration:
 - 1) Water leakage to the interior of the building is a failure.
 - 2) Water observed on interior surfaces of the system is a failure.
 - 3) Water observed on interior surfaces of adjacent systems, originating from the wall system or the transition to the adjacent systems, is a failure.
11. Wet Film Thickness Test (to be performed by installer at time of installation and included on ABAA QAP daily worksheet):
 - a. Test material using wet film gauge to confirm that membrane meets manufacturer's indicated wet film thickness requirements.
 - b. Regularly check per coat per substrate type during installation per ABAA QAP.
 - c. Failure Criteria:
 - 1) A measurement less than manufacturer's required wet film thickness is considered a failure.
 - 2) Provide an inspection report indicating results and include photo documentation.
 - 3) Provide inspection report indicating results and include photo documentation.
12. Dry Film Thickness Test:
 - a. Test material in accordance with manufacturer's requirements to confirm that cured membrane meets manufacturer's indicated dry film thickness requirements.
 - b. Three 1 inch x 4 inch samples removed from separate areas with gypsum facer intact to avoid stretching membrane.
 - c. Test Locations: Once daily per substrate during installation and a minimum of 1 test per major elevation per substrate.
 - 1) Perform one test for the first 2500 sq. ft. of installed material for each wall assembly type.
 - 2) Provide an inspection report in accordance with referenced standard that indicates whether or not the air barrier material has met the minimum adhesion level requirement and include photo documentation.
 - 3) Provide reports within 3 days of test completion.
 - d. Failure Criteria:
 - 1) A measurement less than manufacturer's required dry film thickness is considered a failure.
 - e. Provide an inspection report indicating results and include photo documentation.
13. Infrared Evaluation:
 - a. In general accordance with ASTM E1186 to evaluate air leakage related to the wall assemblies in locations such as but not limited to transitions to adjacent exterior enclosure assemblies, penetrations, and terminations.
 - 1) If anomalies are identified, provide proposed plan to confirm source of anomalies.

- 2) If deficiencies are identified during confirmation process, notify design team, manufacturer, and Owner of cause and extent of deficiencies.
 - 3) Submit manufacturer approved corrective action plan for Owner and Architect's review and approval.
 - 4) Perform infrared evaluation to confirm that deficiencies have been corrected.
14. Air barriers will be considered defective if they do not pass tests and inspections.
- a. Wet Film Thickness: Apply additional air-barrier material, according to manufacturer's written instructions, where inspection results indicate insufficient thickness.
 - b. Upon failure of dry film testing or Adhesion Testing:
 - 1) Determine cause of failure.
 - 2) Provide one additional test for each occurrence of failure.
 - 3) Repair deficient air barrier components per manufacturer's recommendations.
 - 4) Repair tested areas per manufacturer's recommendations.
 - c. Upon failure of E1186 and E1105 testing:
 - 1) Determine cause of failure.
 - 2) Repair per manufacturer's recommendations and retest deficient air barrier components.
 - 3) Determine if deficient conditions are present elsewhere on the building and repair per manufacturer's recommendations.
 - 4) Provide two additional tests for each occurrence of failure.
- F. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.
- G. Clean air barrier materials that were affected by testing procedures to a level equal to or better than the original condition after testing is complete using cleaning agents and procedures recommended by manufacturer of affected construction.
- H. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.
- 3.7 CLEANING AND PROTECTION
- A. Protect air-barrier system from damage during application and remainder of construction period, according to manufacturer's written instructions.
1. Protect air barrier from exposure to UV light and harmful weather exposure as required by manufacturer. If exposed to these conditions for longer than allowed by manufacturer, remove and replace air barrier or install additional, full-thickness, air-barrier application after repairing and preparing the overexposed membrane according to air-barrier manufacturer's written instructions.
 2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.
- B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended by manufacturer of affected construction.
- C. Remove masking materials after installation.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 07 3116 - METAL SHINGLES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Metal shingles.
 - 2. Underlayment materials
 - 3. Sheet metal flashing and trim.
 - 4. Ridge vents.
- B. Disturbance of Existing Roofing:
 - 1. The existing roofing is covered by an existing roofing **[bond] [warranty] [maintenance agreement]**. Contact the roofing manufacturing and installation/maintenance companies for the existing roofing, and ensure that the parties involved are given the opportunity to fulfill their requirements and maintain their interests. Do not disturb the existing roofing until the existing roofing companies and the Owner are in agreement with the plans for addressing disturbance of existing roofing. Document and distribute the agreement to all appropriate parties. Engage existing roofing installation/maintenance firm as necessary.
 - 2. The existing roofing installation/maintenance firm is: **[provide name and contact information]**.
 - 3. Contact the Owner to determine the status of existing roofing warranty/maintenance agreement, and the firm(s) involved.
- C. Related Requirements:
 - 1. Section 07 4113.13 "Formed Metal Roof Panels" for sheet metal roofing panels that are installed as single panels extending from eave to ridge.
 - 2. Section 07 7253 "Snow Guards" for prefabricated devices designed to hold snow on the roof surface, allowing it to melt and drain off slowly.

1.2 ALLOWANCES

- A. See Section 01 2100 "Allowances" for description of allowances affecting items specified under this Section.

1.3 UNIT PRICES

- A. See Section 01 2200 "Unit Prices" for description of unit prices affecting items specified under this Section.

1.4 ALTERNATES

- A. See Section 01 2300 "Alternates" for description of alternates affecting items specified under this Section.

1.5 DEFINITIONS

- A. Roofing Terminology: See ASTM D1079 for definitions of terms related to roofing Work in this Section.

1.6 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. <Insert participant requirements>.

1.7 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required **[Product Data submittal]** and **[Samples submittal]**. Ensure compliance with requirements included in **[Section 01 3300 "Submittal Procedures."] [Section 07 0413 "Common Submittal Requirements for Thermal and Moisture Protection."]**
- B. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each of the following:
 - 1. Metal shingles.
 - 2. Underlayment materials.
 - 3. Ridge vents.
 - 4. Sealant.
- C. Sustainable Design Submittals:
 - 1. Product Test Reports: For roof materials, documentation indicating that roof materials comply with Solar Reflectance Index requirements.
 - 2. Environmental Product Declaration: For each product.
 - 3. Health Product Declaration: For each product.
 - 4. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- D. Shop Drawings: For metal shingles. Include roof plans; sections at hips, gables, ridges, valleys, and eaves; details of metal shingles and joint patterns, flashing, trim, accessories, and attachments to other Work.
- E. Samples: For each exposed product and for each color and texture specified, in manufacturer's standard size.
- F. Samples for Initial Selection:
 - 1. For each type of metal shingle.
 - 2. For each type of accessory involving color selection.
- G. Samples for Verification: Full-size Samples of each type and finish of metal shingle indicated.

1.8 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For metal shingles to include in maintenance manuals.
- B. Materials warranties.
- C. Roofing Installer's warranty.

1.9 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Metal Shingles: [100 sq. ft. (9.3 sq. m)] **<Insert area>** of exposed area, in each type and color, in unbroken bundles.

1.10 QUALITY ASSURANCE

- A. Provide the following upon request:
 - 1. Product Test Reports: For metal shingles, for tests performed by a qualified testing agency.
 - 2. Evaluation Reports: From **[an agency acceptable to authorities having jurisdiction]** **[ICC-ES]** **<Insert evaluation agency>**, indicating that product is suitable for intended use under applicable building codes for the following:
 - a. Polymer-modified bitumen sheet underlayment.
 - b. Synthetic underlayment.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Build mockups of metal shingles, including related roofing materials.
 - a. Size: [48 inches (1219 mm) **long by** 96 inches (2438 mm) **wide**] **<Insert dimensions>**.
 - b. Include gutter and downspout complying with requirements in **[Section 07 6200 "Sheet Metal Flashing and Trim.]"** **[Section 07 7100 "Roof Specialties.]"**
 - 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Store metal shingle materials in a dry, well-ventilated location protected from weather and moisture in accordance with manufacturer's written instructions. Do not allow metal shingles to contact with other materials that might cause staining, denting, or other surface damage. Store metal shingle materials away from uncured and wet concrete and masonry.
 - 1. Retain strippable protective covering on metal shingles during installation.
- B. Store underlayment rolls in a dry, well-ventilated location protected from weather, sunlight, and moisture in accordance with manufacturer's written instructions.
 - 1. Store on end, on pallets or other raised surfaces.
 - 2. Do not double-stack rolls.
- C. Protect unused underlayment from weather, sunlight, and moisture when left overnight or when roofing Work is not in progress.
- D. Handle, store, and place roofing materials in a manner to prevent damage to roof deck or structural supporting members.

1.12 FIELD CONDITIONS

- A. Environmental Limitations: Proceed with installation only when existing and forecasted weather conditions permit product installation and related Work to be performed in accordance with manufacturer's written instructions and warranty requirements.
1. Install self-adhering, polymer-modified bitumen sheet underlayment within the range of ambient and substrate temperatures recommended in writing by manufacturer.

1.13 WARRANTY

- A. Materials Warranty: Manufacturer agrees to repair or replace metal shingles and accessories that fail within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures including wind uplift.
 - b. Water penetration[**and hail perforation**].
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - d. High-Performance Organic Coating: Deterioration of fluoropolymer finish including, but not limited to, the following:
 - 1) Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - 2) Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - 3) Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - e. **<Insert failure modes>**.
 2. Metal Shingle Warranty Period: [15] [25] [50] **<Insert number>** years from date of Substantial Completion.
 3. High-Performance Organic Coating Warranty Period: [10] [20] **<Insert number>** years from date of Substantial Completion.
- B. Roofing Installer's Warranty: On warranty form at end of this Section, signed by Installer, in which Installer agrees to repair or replace components of metal shingle roofing that fail in materials or workmanship within specified warranty period.
1. Warranty Period: [Two] [Five] **<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of product from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Exterior Fire-Test Exposure: Provide metal shingles and related roofing materials identical to those of assemblies tested for Class A fire resistance in accordance with ASTM E108 or UL 790 by Underwriters Laboratories or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify products with appropriate markings of applicable testing agency.

- B. Wind-Uplift Resistance: Provide metal shingle assemblies that comply with the following wind-uplift requirements:
 - 1. Class: [15] [30] [60] [90] when tested in accordance with UL 580.
 - 2. Uplift Resistance: [75 lbf/sq. ft. (3.6 kPa)] [120 lbf/sq. ft. (5.75 kPa)] [165 lbf/sq. ft. (7.9 kPa)] <Insert value> when tested in accordance with UL 1897.
- C. Impact Resistance: [Class 3] [Class 4] <Insert class designation> when tested in accordance with UL 2218.
- D. Energy Performance, ENERGY STAR: Provide metal shingles that are listed on the DOE's "ENERGY STAR Roof Product List" for steep-slope roof products.
- E. Heat Island Effect - Steep Roof: Three-year-aged SRI not less than 32 or initial SRI not less than 39 when calculated in accordance with ASTM E1980 based on testing identical products by a qualified testing agency.

2.3 METAL SHINGLES

- A. Copper, Individual Shingles: Factory-formed, interlocking rectangular units.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. ATAS International, Inc.
 - b. Reinke Shakes; Division of Jame Kari LLC.
 - c. Zappone Manufacturing.
 - 2. Material: Copper sheet, minimum 16 oz./sq. ft. (0.55 mm thick) .
 - 3. Exposure: 12 by 8 inches (305 by 203 mm) 13-1/2 by 13-1/2 inches (343 by 343 mm) 14-1/2 by 8-1/8 inches (368 by 206 mm) .
 - 4. Features: **[Polystyrene backing]** <Insert requirements>.
 - 5. Finish: Pre-patinated dark brown .
- B. Finish Protection: Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

2.4 SHEET METAL MATERIALS

- A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than <Insert value> percent.
- B. Copper Sheet: ASTM B370; Temper H00, cold rolled unless Temper 060 is required for forming.
 - 1. Pre-Patinated Finish: Pre-patinated in accordance with ASTM B882.

2.5 UNDERLAYMENT MATERIALS

- A. Asphalt-Saturated Felt: Organic felt, nonperforated and complying with the following.
 - 1. ASTM D226/D226M: Type I Type II.

- B. Polymer-Modified Bitumen Sheet, Mechanically Fastened: Styrene-butadiene-styrene- (SBS) modified asphalt, glass-fiber-mat-reinforced sheet; minimum 55-mil (1.4-mm) nominal thickness; recommended in writing by manufacturer and acceptable to authorities having jurisdiction for use as underlayment in metal steep-slope roofing systems; designed for mechanical fastening; and with manufacturer's standard non-abrasive, slip-resistant surface that will not scratch the underside of metal shingles. Granular or sand surfacings are unacceptable.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Atlas Roofing Corporation - Polyiso.
 - b. Boral USA; Boral Roofing LLC.
 - c. G.A.P. Roofing, Inc.
 - d. GMC Roofing & Building Paper Products, Inc.
 - e. Tarco.
 2. **<Insert testing requirements>.**

2.6 SHEET METAL FLASHING AND TRIM

- A. Sheet Metal Flashing and Trim: Metal shingle manufacturer's flashing and trim components matching shingle material, color, and finish unless otherwise specified in this Section, indicated on Drawings, or recommended in writing by metal shingle manufacturer. Fabricate to sizes and configurations required for a weathertight installation. Unless otherwise specified in this Section or indicated on Drawings, fabricate sheet metal flashing and trim to comply with recommendations that apply to design, dimensions, metal, and other characteristics of the item in SMACNA's "Architectural Sheet Metal Manual."
1. Valley Flashing: Fabricate to extend not less than 8 inches (203 mm) from the centerline of the valley with a splash-diverter rib not less than 3/4 inch (19 mm) high at the flowline formed as part of the flashing.

2.7 RIDGE VENTS

- A. Ridge Vents: Metal shingle manufacturer's continuous vented ridge caps matching material and finish of metal shingles with insect screen or insect-resisting geotextile filter strips ; for use with specified metal shingles.
1. Minimum Net Free Area: **<Insert free area>.**
 2. Accessories: Splices, end caps, and other accessories matching metal and finish.

2.8 ACCESSORIES

- A. Sealant: ASTM C920, Type S, Grade NS, one-part, non-sag elastomeric polymer joint sealant as recommended in writing by metal shingle manufacturer for installation indicated; of class and use classifications required to seal joints and remain watertight. Where sealant is exposed, provide in color matching shingle.
- B. Sheet Metal Fasteners: Noncorrosive screws, nails, and anchors designed to withstand design loads and recommended in writing by metal shingle manufacturer.
1. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
 2. Fasteners for Copper Sheet: Copper, hardware bronze, or Series 300 stainless steel.

- C. Underlayment Nails: Aluminum, stainless steel, or hot-dip galvanized-steel wire nails with low-profile metal or plastic caps, 1-inch- (25-mm-) minimum diameter.
 - 1. Provide with minimum 0.0134-inch- (0.34-mm-) thick metal cap, 0.010-inch- (0.25-mm-) thick power-driven metal cap, or 0.035-inch- (0.89-mm-) thick plastic cap; and with minimum 0.083-inch- (2.11-mm-) thick ring shank or 0.091-inch- (2.31-mm-) thick smooth shank of length to penetrate at least 3/4 inch (19 mm) into roof sheathing or to penetrate through roof sheathing less than 3/4 inch (19 mm) thick.
 - 2. Where nails are in contact with metal shingles or flashing, use nails made from same metal as metal shingles.
- D. <Insert snow-guard requirements>.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Examine roof sheathing to verify that sheathing joints are supported by framing and blocking, that tops of fasteners are flush with surface, and that installation is within flatness tolerances.
 - 2. Verify that substrate is sound, dry to the maximum moisture content recommended in writing by metal shingle manufacturer, smooth, clean, sloped for drainage, and completely anchored and that provisions have been made for flashings and penetrations through metal shingles.
 - 3. Verify that vent stacks and other penetrations through roofing are installed and securely fastened.
- B. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF UNDERLAYMENT MATERIALS

- A. Comply with metal shingle and underlayment manufacturers' written installation instructions and with recommendations in NRCA's "The NRCA Roofing Manual: Steep-Slope Roof Systems" applicable to products and applications indicated unless more stringent requirements are specified in this Section or indicated on Drawings.
- B. Asphalt-Saturated Felt: Install on roof deck parallel with and starting at eaves and fasten with underlayment nails.
 - 1. Single-Layer Installation:
 - a. Lap sides a minimum of [2 inches (51 mm)] [4 inches (102 mm)] over underlying course.
 - b. Lap ends a minimum of 4 inches (102 mm).
 - c. Stagger end laps between succeeding courses at least 72 inches (1829 mm).
 - 2. Double-Layer Installation:
 - a. Install a 19-inch- (483-mm-) wide starter course at eaves and completely cover with a 36-inch- (914-mm-) wide second course.

- b. Install succeeding 36-inch- (914-mm-) wide courses lapping previous courses 19 inches (483 mm) in shingle fashion.
 - c. Lap ends a minimum of 4 inches (102 mm).
 - d. Stagger end laps between succeeding courses at least 72 inches (1829 mm).
 - e. Apply a continuous layer of asphalt roofing cement over starter course and on felt surface to be concealed by succeeding courses as each felt course is installed. Apply **[over entire roof] [at locations indicated on Drawings]**.
 - 3. Install felt underlayment on roof deck not covered by self-adhering, polymer-modified bitumen sheet unless otherwise specified in this Section or indicated on Drawings.
 - a. Lap sides of felt over self-adhering sheet not less than 4 inches (102 mm) in direction that sheds water.
 - b. Lap ends of felt not less than 6 inches (152 mm) over self-adhering sheet underlayment.
 - 4. Install fasteners in a grid pattern of 12 inches (305 mm) between side laps with 6-inch (152-mm) spacing at side and end laps.
 - 5. Terminate felt **[flush] [extended up not less than 4 inches (102 mm)]** **<Insert requirements>** against sidewalls, curbs, chimneys, and other roof projections.
- C. Polymer-Modified Bitumen Sheet, Mechanically Fastened: Install on roof deck parallel with and starting at eaves. Fasten with underlayment nails.
 - 1. Single-Layer Installation:
 - a. Lap sides a minimum of [2 inches (51 mm)] [4 inches (102 mm)] over underlying course.
 - b. Lap ends a minimum of 6 inches (152 mm).
 - c. Stagger end laps between succeeding courses at least 72 inches (1829 mm).
 - 2. Double-Layer Installation:
 - a. Install in overlapping layers with a half-width plus 1-inch- (25-mm-) wide starter course at eaves completely covered by full-width second course. Install succeeding courses lapping previous courses by a half-width plus 1 inch (25 mm) in shingle fashion.
 - b. Lap ends a minimum of 6 inches (152 mm).
 - c. Stagger end laps between succeeding courses at least 72 inches (1829 mm).
 - 3. Install mechanically fastened sheet on roof deck not covered by self-adhering, polymer-modified bitumen sheet unless otherwise specified in this Section or indicated on Drawings.
 - a. Lap sides of mechanically fastened sheets over self-adhering sheet not less than 4 inches (102 mm) in direction to shed water.
 - b. Lap ends of mechanically fastened sheets not less than 6 inches (152 mm) over self-adhering sheets.
 - 4. Install fasteners in a grid pattern of 12 inches (305 mm) between side laps with 6-inch (152-mm) spacing at side and end laps.
 - 5. Terminate sheets **[flush] [extended up not less than 4 inches (102 mm)]** **<Insert requirements>** against sidewalls, curbs, chimneys, and other roof projections.
- D. Valley Underlayment: Install one layer of 36-inch- (914-mm-) wide underlayment centered in valley, running full length of valley, and on top of underlayment on field of roof that is woven through valley. Install all layers of underlayment in and through valley tight with no bridging.
 - 1. Use same underlayment as installed on field of roof.
 - 2. Lap ends at least 12 inches (305 mm) in direction that sheds water, and seal with asphalt roofing cement.

3. Fasten to roof deck with underlayment nails located as far from valley center as possible and only to extent necessary to hold underlayment in place until installation of valley flashing.
4. Solidly cement valley underlayment to roof-field underlayment that is woven through valley using asphalt roofing cement.

3.3 INSTALLATION OF SHEET METAL FLASHINGS AND TRIM

- A. Install metal flashings and trim in accordance with manufacturer's written instructions and recommendations in NRCA's "The NRCA Roofing Manual: Steep-Slope Roof Systems" unless more stringent requirements are specified in this Section or indicated on Drawings.
 1. Install with minimum 4-inch (102-mm) end laps.

3.4 INSTALLATION OF RIDGE VENTS

- A. Install ridge vents with end closures at locations indicated on Drawings in accordance with manufacturers' written instructions unless more stringent requirements are specified in this Section or indicated on Drawings.

3.5 INSTALLATION OF ACCESSORIES

- A. Install accessories in accordance with manufacturers' written instructions unless more stringent requirements are specified in this Section or indicated on Drawings.
- B. Battens: Install battens in accordance with metal shingle manufacturer's written instructions.
- C. Metal Protection: Where dissimilar metals contact each other, protect against galvanic action by painting contact surfaces with bituminous coating, by applying self-adhering, polymer-modified bitumen sheet to each contact surface, or by other means of permanent separation recommended in writing by manufacturer of metal shingles or of the metals in contact.

3.6 INSTALLATION OF METAL SHINGLES

- A. Install metal shingles in accordance with manufacturer's written instructions true in line.
- B. Maintain uniform exposure and coursing of metal shingles throughout roof.
- C. Apply sealant between shingles, flashing, trim, and exposed fasteners to achieve a weathertight system.
- D. Interlock and overlap shingles, and [stagger end joints from] [align joints of tile-form] shingle courses above and below.
- E. Metal Protection: Where dissimilar metals contact each other, protect against galvanic action by painting contact surfaces with bituminous coating, by applying self-adhering, polymer-modified bitumen sheet to each contact surface, or by other means of permanent separation recommended in writing by manufacturer of metal shingles or of the metals in contact.
 1. Do not use graphite pencils to mark metal surfaces.

3.7 ADJUSTING

- A. Remove and replace damaged or deformed metal shingles. Replace shingles with damaged or deteriorated finishes and other components of the Work that cannot be successfully repaired by finish touchup or similar minor repair procedures.
- B. Remove temporary protective coverings and strippable films as metal shingles are installed unless otherwise indicated in manufacturer's written installation instructions.
- C. On completion of installation, touch up minor nicks and abrasions in finish, in accordance with manufacturer's written instructions.
- D. Remove excess sealants.

3.8 ROOFING INSTALLER'S WARRANTY

- A. WHEREAS **<Insert name>** of **<Insert address>**, herein called the "Roofing Installer," has performed roofing and associated work ("the work") on the following project:
 - 1. Owner: **<Insert name of Owner>**.
 - 2. Owner Address: **<Insert address>**.
 - 3. Building Name/Type: **<Insert information>**.
 - 4. Building Address: **<Insert address>**.
 - 5. Area of the Work: **<Insert information>**.
 - 6. Acceptance Date: **<Insert date>**.
 - 7. Warranty Period: **<Insert time>**.
 - 8. Expiration Date: **<Insert date>**.
- B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant the work against leaks and faulty or defective materials and workmanship for designated Warranty Period,
- C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that, during Warranty Period, Roofing Installer will, at Roofing Installer's own cost and expense, make or cause to be made such repairs to or replacements of the work as are necessary to correct faulty and defective work and as are necessary to maintain the work in a watertight condition.
- D. This Warranty is made subject to the following terms and conditions:
 - 1. Specifically excluded from this Warranty are damages to the work and other parts of the building, and to building contents, caused by:
 - a. Lightning;
 - b. Peak gust wind speed exceeding **<Insert wind speed>** mph (m/s);
 - c. Fire;
 - d. Failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;
 - e. Faulty construction of copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
 - f. Vapor condensation on bottom of roofing; and

- g. Activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.
 2. When the work has been damaged by any of foregoing causes, Warranty is to be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.
 3. Roofing Installer is responsible for damage to the work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of the work.
 4. During Warranty Period, if Owner allows alteration of the work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty becomes null and void on date of the alterations, but only to the extent the alterations affect the work covered by this Warranty. If Owner engages Roofing Installer to perform the alterations, Warranty does not become null and void unless Roofing Installer, before starting the alterations, notified Owner in writing, showing reasonable cause for claim, that the alterations would likely damage or deteriorate the work, thereby reasonably justifying a limitation or termination of this Warranty.
 5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a use or service more severe than originally specified, this Warranty becomes null and void on date of the change, but only to the extent the change affects the work covered by this Warranty.
 6. Owner promptly notifies Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and affords reasonable opportunity for Roofing Installer to inspect the work and to examine evidence of such leaks, defects, or deterioration.
 7. This Warranty is recognized to be the only warranty of Roofing Installer on the work and does not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty does not operate to relieve Roofing Installer of responsibility for performance of the work in accordance with requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.
- E. IN WITNESS THEREOF, this instrument has been duly executed this **<Insert day>** day of **<Insert month>**, **<Insert year>**.
1. Authorized Signature: **<Insert signature>**.
 2. Name: **<Insert name>**.
 3. Title: **<Insert title>**.

END OF SECTION

SECTION 07 6200 - SHEET METAL FLASHING AND TRIM**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes: Custom flashing and trim fabrications, made from the following:
 - 1. Sheet metal materials.
 - 2. Underlayment.
 - 3. Miscellaneous materials.
- B. Related Requirements:
 - 1. Section 06 1000 "Rough Carpentry" for wood nailers, curbs, and blocking.
 - 2. Section <Insert Section number> "<Insert Section title>" for [materials and]installation of manufactured sheet metal through-wall flashing and trim integral with masonry.
 - 3. Section <Insert Section number> "<Insert Section title>" for [materials and]installation of sheet metal flashing and trim integral with roofing.
 - 4. Section <Insert Section number> "<Insert Section title>" for sheet metal flashing and trim integral with metal wall panels.
 - 5. Section 07 7100 "Roof Specialties" for manufactured copings, roof-edge specialties, roof-edge drainage systems, reglets, and counterflashings.
 - 6. Section 07 7200 "Roof Accessories" for set-on-type curbs, equipment supports, roof hatches, vents, and other manufactured roof accessory units.
 - 7. Section 07 9513.13 "Interior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for interior floors, walls, and ceilings.
 - 8. Section 07 9513.16 "Exterior Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies for exterior building walls, soffits, and parapets.
 - 9. Section 07 9513.19 "Parking Deck Expansion Joint Cover Assemblies" for manufactured expansion-joint cover assemblies subject to vehicular traffic.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review special roof details, roof drainage, roof-penetration flashing, equipment curbs, and condition of other construction that affect sheet metal flashing and trim.
 - 3. Review requirements for insurance and certificates if applicable.
 - 4. Review sheet metal flashing observation and repair procedures after flashing installation.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For sheet metal flashing and trim.
 - 1. Plans, elevations, sections, and attachment details.
 - 2. Fabrication and installation layouts, expansion-joint locations, and keyed details. Distinguish between shop- and field-assembled Work.
 - 3. Identification of material, thickness, weight, and finish for each item and location in Project.

4. Details for forming, including profiles, shapes, seams, and dimensions.
 5. Details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
 6. Details of termination points and assemblies.
 7. Details of expansion joints and expansion-joint covers, including showing direction of expansion and contraction from fixed points.
 8. Details of roof-penetration flashing.
 9. Details of edge conditions, including eaves, ridges, valleys, rakes, crickets, flashings, and counterflashings.
 10. Details of special conditions.
 11. Details of connections to adjoining work.
 12. Formed flashing and trim at scale of not less than 1-1/2 inches per 12 inches (1:10).
- C. Samples: For each exposed product and for each color and texture specified, 12 inches (300 mm) long by actual width.
- D. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of exposed finish.
- E. Samples for Verification: Actual sample of finished products for each type of exposed finish for sheet metal and other metal accessories.
1. Sheet Metal Flashing and Trim: [**Manufacturers' standard size**] <Insert size>. Include finished seam with required profile. Include fasteners, cleats, clips, closures, and other attachments.
 2. Anodized Aluminum Samples: Samples to show full range to be expected for each color required.
- F. Sustainable Design Submittals:
1. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than <Insert value> percent.
- 1.4 CLOSEOUT SUBMITTALS
- A. Maintenance Data: For sheet metal flashing and trim, and its accessories.
- 1.5 QUALITY ASSURANCE
- A. Fabricator Qualifications: Entity that employs skilled workers who custom fabricate sheet metal flashing and trim similar to that required for this Project and whose products have a record of successful in-service performance.
- B. Installer Qualifications: Entity that employs [**a supervisor who is an NRCA ProCertified Roofing Foreman or installers who are NRCA ProCertified Architectural Metal Flashings and Accessories Installers**] [**a supervisor who is an NRCA ProCertified Roofing Foreman**] [**a supervisor who is an NRCA ProCertified Roofing Foreman and not less than 20 percent of installers who are NRCA ProCertified Architectural Metal Flashings and Accessories Installers**].
- C. For roof edge flashings and copings that are ANSI/SPRI/FM 4435/ES-1 tested[**and FM Approvals approved**], shop is to be listed as able to fabricate required details as tested and approved.

D. Provide the following upon request:

1. Certificates: For each type of coping and roof edge flashing that is [**ANSI/SPRI/FM 4435/ES-1 tested**] [**and**] [**FM Approvals approved**].
2. Product Test Reports: For each product, for tests performed by a qualified testing agency.
3. Research Reports: For copings and roof edge flashing, from [**an agency acceptable to authority having jurisdiction**] [**ICC-ES**] <Insert evaluation agency> showing compliance with ANSI/SPRI/FM 4435/ES-1.
4. Qualification Statements: For fabricator.

1.6 MOCKUPS

A. Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for fabrication and installation.

1. Build mockup of typical roof [**edge**] [**eave**], including [**built-in gutter**] [**fascia**] [**fascia trim**] [**apron flashing**] <Insert item>, approximately [10 ft. (3.0 m)] <Insert dimension> long, including supporting construction cleats, seams, attachments, [**underlayment**], and accessories.
2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store sheet metal flashing and trim materials in contact with other materials that might cause staining, denting, or other surface damage.

1. Store sheet metal flashing and trim materials away from uncured concrete and masonry.
2. Protect stored sheet metal flashing and trim from contact with water.

B. Protect strippable protective covering on sheet metal flashing and trim from exposure to sunlight and high humidity, except to extent necessary for period of sheet metal flashing and trim installation.

1.8 COORDINATION

A. Coordinate sheet metal flashing and trim layout and seams with sizes and locations of penetrations to be flashed, and joints and seams in adjacent materials.

B. Coordinate sheet metal flashing and trim installation with adjoining roofing and wall materials, joints, and seams to provide leakproof, secure, and noncorrosive installation.

1.9 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.

- b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
- c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
- 2. Finish Warranty Period: [20] [10] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sheet metal flashing and trim assemblies, including cleats, anchors, and fasteners, are to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim are not to rattle, leak, or loosen, and are to remain watertight.
- B. Sheet Metal Standard for Flashing and Trim: Comply with [NRCA's "**The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing**"] [and] [SMACNA's "**Architectural Sheet Metal Manual**"] requirements for dimensions and profiles shown unless more stringent requirements are indicated.
- C. Sheet Metal Standard for Copper: Comply with CDA's "Copper in Architecture Design Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.
- D. SPRI Wind Design Standard: Manufacture and install roof edge flashings and copings tested in accordance with ANSI/SPRI/FM 4435/ES-1 and capable of resisting the following design pressure:
 - 1. Design Pressure: As indicated on Drawings.
- E. FM Approvals Listing: Manufacture and install roof edge flashings and copings that comply with requirements in FM Approvals 4471 as part of a roofing system and that are listed in FM Approvals' "Approval Guide" and approved for windstorm classification, [Class 1A-60] [Class 1A-75] [Class 1A-90] [Class 1A-105] [Class 1A-120] <Insert class>. Identify materials with name of fabricator and design approved by FM Approvals.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 SHEET METAL MATERIALS

- A. Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.
- B. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with minimum ASTM A653/A653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with minimum ASTM A792/A792M, Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.

1. Nominal Thickness: 0.022 inch (0.56 mm) 0.028 inch (0.71 mm) 0.034 inch (0.86 mm) 0.040 inch (1.02 mm) 0.052 inch (1.32 mm).
 2. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than <Insert value> percent.
 3. Surface: Smooth, flat Embossed and mill phosphatized for field painting and with manufacturer's standard clear acrylic coating on both sides.
 4. Exposed Coil-Coated Finish:
 - a. Two-Coat Fluoropolymer: Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - b. Three-Coat Fluoropolymer: Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - c. Mica Fluoropolymer: Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - d. Metallic Fluoropolymer: Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - e. FEVE Fluoropolymer: Two-coat fluoropolymer finish containing 100 percent FEVE resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - f. Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
 5. Color: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range Insert color.
 6. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil (0.013 mm).
- C. Aluminum Sheet: Coil-coated sheet, ASTM B209/B209M, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
1. Thickness: 0.032 inch (0.81 mm) 0.040 inch (1.02 mm) 0.050 inch (1.27 mm) 0.063 inch (1.60 mm).
 2. Surface: Smooth, flat Embossed.
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than <Insert value> percent.
 4. Exposed Coil-Coated Finish:
 - a. Two-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.

- b. Three-Coat Fluoropolymer: AAMA 2605. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - c. Mica Fluoropolymer: AAMA 2605. Two-coat fluoropolymer finish with suspended mica flakes containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - d. Metallic Fluoropolymer: AAMA 2605. Three-coat fluoropolymer finish with suspended metallic flakes containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - e. FEVE Fluoropolymer: AAMA 2605. Two-coat fluoropolymer finish containing 100 percent FEVE resin in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 - f. Siliconized Polyester: Epoxy primer and silicone-modified, polyester-enamel topcoat; with dry film thickness of not less than 0.2 mil (0.005 mm) for primer and 0.8 mil (0.02 mm) for topcoat.
- 5. Color: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from manufacturer's full range Insert color.
 - 6. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil (0.013 mm).
 - 7. Clear Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A41, Class I, 0.018 mm AA-M12C22A31, Class II, 0.010 mm or thicker.
 - 8. Color Anodic Finish, Coil Coated: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm AA-M12C22A32/A34, Class II, 0.010 mm or thicker.
 - a. Color: Champagne Light bronze Medium bronze Dark bronze Black Match Architect's sample As selected by Architect from full range of industry colors and color densities Insert color.
 - b. Color Range: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
 - 9. As-Milled Finish: Mill One-side bright mill Standard one-side bright Standard two-side bright.
 - 10. Alclad Finish: Metallurgically bonded surfacing alloy on both sides, forming aluminum sheet with reflective luster.
 - 11. Factory Prime Coating: Where painting after installation is required, pretreat metal with white or light-colored, factory-applied, baked-on epoxy primer coat; minimum dry film thickness of 0.2 mil (0.005 mm).
- D. Stainless Steel Sheet: ASTM A240/A240M, Type 304 Type 316, dead soft, fully annealed.
- 1. Nominal Thickness: 0.0156 inch (0.396 mm) 0.0188 inch (0.477 mm) 0.0250 inch (0.635 mm) 0.0313 inch (0.795 mm) 0.0375 inch (0.952 mm) 0.0500 inch (1.270 mm).
 - 2. Surface: Smooth, flat Embossed.

3. Exterior Finish: ASTM A480/A480M, No. 2B (bright, cold rolled) ASTM A480/A480M, No. 2D (dull, cold rolled) ASTM A480/A480M, No. 3 (coarse, polished directional satin) ASTM A480/A480M No. 4 Insert finish.
 - a. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 - b. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - 1) Run grain of directional finishes with long dimension of each piece.
 - 2) When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
 4. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert value>** percent.
- E. Copper Sheet: ASTM B370, cold-rolled copper sheet, H00 or H01 temper.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Hussey Copper Ltd.
 - b. Revere Copper Products, Inc.
 2. Thickness: 16 oz./sq. ft. (0.55 mm) 20 oz./sq. ft. (0.68 mm) 24 oz./sq. ft. (0.82 mm).
 3. Nonpatinated, Exposed Finish: Mill.
- F. Zinc-Tin Alloy-Coated Copper Sheet: ASTM B370, cold-rolled copper sheet, H00 temper; coated on both sides with zinc-tin alloy (50 percent zinc, 50 percent tin).
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Revere Copper Products, Inc.
 2. Thickness: 16 oz./sq. ft. (0.55 mm) 20 oz./sq. ft. (0.68 mm) 24 oz./sq. ft. (0.82 mm) 25 oz./sq. ft. (0.87 mm thick).
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert value>** percent.
- G. Zinc Sheet: 99.995 percent electrolytic high-grade zinc with alloy additives of copper (0.08 to 0.20 percent), titanium (0.07 to 0.12 percent), and aluminum (0.015 percent) Zinc, 99 percent pure, alloyed with 0.08 to 1.00 percent copper, 0.06 to 0.20 percent titanium, and up to 0.015 percent aluminum; with manufacturer's standard factory-applied, flexible, protective back coating.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Artazn LLC.
 - b. Rheinzink America.
 2. Thickness: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) 0.048 inch (1.25 mm) 0.059 inch (1.50 mm).
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert value>** percent.
 4. Finish: Bright rolled Preweathered gray Preweathered black Insert finish.

- H. Copper-Clad Stainless Steel Sheet: ASTM B506, annealed Temper O61.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Heyco Metals.
 - b. SEMCO Southeastern Metals, A Gibraltar Industries Company.
 2. Thickness: 0.016 inch (0.40 mm) 0.018 inch (0.46 mm) 0.027 inch (0.69 mm).
 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than **<Insert value>** percent.
 4. Nonpatinated, Exposed Finish: Mill.
- I. Lead Sheet: ASTM B749 lead sheet.
1. Thickness: 4 lb (1.8 kg).

2.3 UNDERLAYMENT

- A. Synthetic Underlayment: Laminated or reinforced, woven polyethylene or polypropylene, synthetic roofing underlayment; bitumen free; slip resistant; suitable for high temperatures over 220 deg F (111 deg C); and complying with physical requirements of ASTM D226/D226M for Type I and Type II felts.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Atlas Molded Products, a division of Atlas Roofing Corporation.
 - b. Intertape Polymer Group.
 - c. Kirsch Building Products.
 - d. SDP Advanced Polymer Products Inc.
- B. Self-Adhering, High-Temperature Sheet Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils (0.76 mm) thick, specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer when recommended by underlayment manufacturer.
1. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D1970/D1970M.
 2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (minus 29 deg C) or lower; ASTM D1970/D1970M.
 3. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. ATAS International, Inc.
 - b. Carlisle WIP Products; a brand of Carlisle Construction Materials.
 - c. GCP Applied Technologies Inc.
 - d. Henry Company; a Carlisle company.
 - e. Owens Corning.
 - f. Polyglass U.S.A., Inc.
 - g. Protecto Wrap Company.
 - h. SDP Advanced Polymer Products Inc.

- C. Felt: ASTM D226/D226M, Type II (No. 30), asphalt-saturated organic felt; nonperforated.
- D. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft. (0.16 kg/sq. m) minimum, of type required for application.

2.4 MISCELLANEOUS MATERIALS

- A. Provide materials and types of fasteners[, **solder**], protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal[**or manufactured item**] unless otherwise indicated.
- B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal[**or manufactured item**].
 - 1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.
 - a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
 - b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
 - c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.
 - 2. Fasteners for Zinc-Coated (Galvanized) or Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.
 - 3. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
 - 4. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.
 - 5. Fasteners for Copper, Zinc-Tin Alloy-Coated Copper, or Copper-Clad Stainless Steel Sheet: Copper, hardware bronze or passivated Series 300 stainless steel.
 - 6. Fasteners for Zinc Sheet: Series 300 stainless steel[**or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M**].
- C. Solder:
 - 1. For Zinc-Coated (Galvanized) Steel: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead with maximum lead content of 0.2 percent.
 - 2. For Stainless Steel: ASTM B32, Grade Sn60 Grade Sn96, with acid flux of type recommended by stainless steel sheet manufacturer.
 - 3. For Copper or Copper-Clad Stainless Steel: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead with maximum lead content of 0.2 percent.
 - 4. For Zinc-Tin Alloy-Coated Copper: ASTM B32, 100 percent tin, with maximum lead content of 0.2 percent, as recommended by sheet metal manufacturer.
 - 5. For Zinc: ASTM B32, 40 percent tin and 60 percent lead with low antimony, with maximum lead content of 0.2 percent, as recommended by zinc manufacturer.
- D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.

- E. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polysulfide silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.
- F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for hooked-type expansion joints with limited movement.
- G. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.
- H. Bituminous Coating: Cold-applied asphalt emulsion in accordance with ASTM D1187/D1187M.
- I. Asphalt Roofing Cement: ASTM D4586/D4586M, asbestos free, of consistency required for application.
- J. Reglets: Units of type, material, and profile required, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions with interlocking counterflashing on exterior face, of same metal as reglet.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Cheney Flashing Company.
 - b. Fry Reglet Corporation.
 - c. Heckmann Building Products, Inc.
 - d. Hohmann & Barnard, Inc.
 - e. Keystone Flashing Company, Inc.
 - f. Metal-Era, Inc.
 - g. OMG Roofing Products; a Division of OMG, Inc.
 - 2. Material: Galvanized steel, 0.022 inch (0.56 mm) thick Aluminum, 0.024 inch (0.61 mm) thick Stainless steel, 0.0188 inch (0.477 mm) thick Copper, 16 oz./sq. ft. (0.55 mm thick).
 - 3. Surface-Mounted Type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.
 - 4. Stucco Type: Provide with upturned fastening flange and extension leg of length to match thickness of applied finish materials.
 - 5. Concrete Type: Provide temporary closure tape to keep reglet free of concrete materials, special fasteners for attaching reglet to concrete forms, and guides to ensure alignment of reglet section ends.
 - 6. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
 - 7. Accessories:
 - a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.
 - b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing's lower edge.

8. Finish: Mill With manufacturer's standard color coating Insert finish.

2.5 FABRICATION, GENERAL

- A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.
 1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
 2. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
 3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
 4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
 5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.
- B. Fabrication Tolerances:
 1. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.
 2. Fabricate sheet metal flashing and trim that is capable of installation to tolerances specified.
- C. Expansion Provisions: Form metal for thermal expansion of exposed flashing and trim.
 1. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with butyl sealant concealed within joints.
 2. Use lapped expansion joints only where indicated on Drawings.
- D. Sealant Joints: Where movable, nonexpansion-type joints are required, form metal in accordance with cited sheet metal standard to provide for proper installation of elastomeric sealant.
- E. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.
- F. Fabricate cleats and attachment devices of sizes as recommended by cited sheet metal standard[**and by FM Global Property Loss Prevention Data Sheet 1-49**] for application, but not less than thickness of metal being secured.
- G. Seams:
 1. Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
 2. Fabricate nonmoving seams with flat-lock seams. Form seams and seal with elastomeric sealant unless otherwise recommended by sealant manufacturer for intended use.[**Rivet joints where necessary for strength.**]
 3. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer.[**Rivet joints where necessary for strength.**]
- H. Do not use graphite pencils to mark metal surfaces.

- I. Cap Flashing/Counterflashing Fabrication - General: Provide two-piece metal cap flashings, consisting of an upper receiver portion and a lower portion extending over the composition flashing, unless otherwise specified or indicated.
 1. Cap Flashing/Counterflashing Fabrication - Two Piece
 - a. Fabricate the receiver portion with outer edge formed into a double fold turned down one inch (25 mm), unless otherwise indicated, and as follows:
 - 1) At new masonry walls, extend the receiver portion into the wall as indicated, terminated with 1/4 inch (6 mm) upstand edge, unless indicated to be higher.
 - 2) At walls faced with metal siding or pre-formed metal panels, extend the receiver portion into the wall as indicated, and terminated with edge folded over support.
 - 3) At concrete and existing masonry walls, extend the receiver portion into an embedded reglet, sawcut in the profile indicated for a reglet, or form the receiver portion to retain sealant as indicated, using a 3/16 by one inch (5 by 25 mm) stainless steel clamping bar.
 - 4) At parapet, extend the receiver portion over wood blocking as indicated.
 - 5) At parapet, extend the receiver portion as indicated and form the upper edge to engage the double fold of coping
 - b. Form the upper edge of the lower portion of metal cap flashing to engage in the double fold of receiver portion, bent to provide spring action against the base flashing, fold the lower edge folded back 1/2 inch (13 mm) and lap composition base flashing not less than 4 inches (100 mm).
 - c. Lap ends of each length of both portions of metal cap flashing not less than 3 inches (75 mm). Weld or solder corner joints. Return ends at roof edge into reglet or wall.
 2. Cap Flashing/Counterflashing Fabrication - One Piece: Provide one-piece cap flashing at roof curbs, with top edge formed to retain metal joint sealant and bottom edge folded 1/2 inch (13 mm) to provide drip.

2.6 ROOF-DRAINAGE SHEET METAL FABRICATIONS

- A. Hanging Gutters:
 1. Fabricate to cross section required, complete with end pieces, outlet tubes, and other accessories as required.
 2. Fabricate in minimum 96-inch- (2400-mm-) long sections.
 3. Furnish flat-stock gutter brackets and **[flat-stock] [twisted]** gutter spacers and straps fabricated from same metal as gutters, of size recommended by cited sheet metal standard, but with thickness not less than **[twice the gutter thickness] [dimension indicated on Drawings] <Insert dimension>**.
 4. Fabricate expansion joints, expansion-joint covers, **[gutter bead reinforcing bars,]** and gutter accessories from same metal as gutters. **[Shop fabricate interior and exterior corners.]**
 5. Gutter Profile: Style A Style B Style C Style D Style E Style F Style G Style H Style I Style J Style K Style L in accordance with cited sheet metal standard.
 6. Expansion Joints: Lap type Butt type Butt type with cover plate Built in.
 7. Accessories: Continuous, removable leaf screen with sheet metal frame and hardware cloth screen Wire-ball downspout strainer Valley baffles.
 8. Gutters with Girth up to 15 Inches (380 mm): Fabricate from the following materials:
 - a. Galvanized Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.

- c. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
- d. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
- e. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
- f. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
- g. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
- h. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.
- 9. Gutters with Girth 16 to 20 Inches (410 to 510 mm): Fabricate from the following materials:
 - a. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - c. Aluminum: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - d. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 - e. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - f. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - g. Zinc: 0.039 inch (1.00 mm) 0.048 inch (1.25 mm) Insert dimension thick.
 - h. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.
- 10. Gutters with Girth 21 to 25 Inches (530 to 640 mm): Fabricate from the following materials:
 - a. Galvanized Steel: [0.034 inch (0.86 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.034 inch (0.86 mm)] <Insert dimension> thick.
 - c. Aluminum: [0.050 inch (1.27 mm)] <Insert dimension> thick.
 - d. Stainless Steel: [0.0250 inch (0.635 mm)] <Insert dimension> thick.
 - e. Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - f. Zinc-Tin Alloy-Coated Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - g. Zinc: 0.048 inch (1.25 mm) 0.059 inch (1.50 mm) Insert dimension thick.
 - h. Copper-Clad Stainless Steel: [0.027 inch (0.69 mm)] <Insert dimension> thick.
- 11. Gutters with Girth 26 to 30 Inches (660 to 760 mm): Fabricate from the following materials:
 - a. Galvanized Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - c. Aluminum: [0.063 inch (1.60 mm)] <Insert dimension> thick.
 - d. Stainless Steel: [0.0313 inch (0.795 mm)] <Insert dimension> thick.
 - e. Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 - f. Zinc-Tin Alloy-Coated Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
- 12. Gutters with Girth 31 to 35 Inches (790 to 890 mm): Fabricate from the following materials:
 - a. Galvanized Steel: [0.052 inch (1.32 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.052 inch (1.32 mm)] <Insert dimension> thick.
 - c. Stainless Steel: [0.0375 inch (0.952 mm)] <Insert dimension> thick.
 - d. Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 - e. Zinc-Tin Alloy-Coated Copper: [25 oz./sq. ft. (0.87 mm thick)] <Insert value>.

B. Built-in Gutters:

- 1. Fabricate to cross section required, with riveted and soldered joints, complete with end pieces, outlet tubes, and other special accessories as required.

2. Fabricate in minimum 96-inch- (2400-mm-) long sections. Fabricate expansion joints and accessories from same metal as gutters unless otherwise indicated.
 3. Fabricate gutters with built-in expansion joints[**and gutter-end expansion joints at walls**].
 4. Accessories: Continuous, removable leaf screen with sheet metal frame and hardware cloth screen Bronze wire-ball downspout strainer Wire-ball downspout strainer.
 5. Fabricate from the following materials:
 - a. Stainless Steel: [0.0156 inch (0.396 mm)] **<Insert dimension>** thick.
 - b. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 - c. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 - d. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - e. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] **<Insert dimension>** thick.
- C. Downspouts: Fabricate round rectangular open-face downspouts to dimensions indicated on Drawings, complete with mitered elbows. Furnish with metal hangers from same material as downspouts and anchors Insert material.[**Shop fabricate elbows.**]
1. Fabricated Hanger Style: Fig. 1-35A Fig. 1-35B Fig. 1-35C Fig. 1-35D Fig. 1-35E Fig. 1-35F Fig. 1-35G Fig. 1-35H Fig. 1-35I Fig. 1-35J in accordance with SMACNA's "Architectural Sheet Metal Manual."
 2. Fabricate from the following materials:
 - a. Galvanized Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
 - c. Aluminum: [0.024 inch (0.61 mm)] **<Insert dimension>** thick.
 - d. Stainless Steel: [0.0156 inch (0.396 mm)] **<Insert dimension>** thick.
 - e. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 - f. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 - g. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - h. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] **<Insert dimension>** thick.
- D. Parapet Scuppers: Fabricate scuppers to dimensions required, with closure flange trim to exterior, 4-inch- (100-mm-) wide wall flanges to interior, and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof.[**Fasten gravel guard angles to base of scupper.**] Fabricate from the following materials:
1. Galvanized Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
 3. Aluminum: [0.032 inch (0.81 mm)] **<Insert dimension>** thick.
 4. Stainless Steel: [0.0188 inch (0.477 mm)] **<Insert dimension>** thick.
 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 8. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] **<Insert dimension>** thick.
- E. Conductor Heads: Fabricate conductor heads with flanged back and stiffened top edge and of dimensions and shape required, complete with outlet tubes, exterior flange trim, built-in overflows. Fabricate from the following materials:
1. Galvanized Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
 3. Aluminum: [0.032 inch (0.81 mm)] **<Insert dimension>** thick.
 4. Stainless Steel: [0.0156 inch (0.396 mm)] **<Insert dimension>** thick.

5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.

F. Splash Pans: Fabricate to dimensions and shape required and from the following materials:

1. Aluminum: [0.040 inch (1.02 mm)] <Insert dimension> thick.
2. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
3. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
4. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
5. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
6. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.

2.7 LOW-SLOPE ROOF SHEET METAL FABRICATIONS

A. Roof Edge Flashing (Gravel Stop) and Fascia Cap: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 12 ft. (3.6 m) long sections. Furnish with 6-inch- (150-mm-) wide, joint cover plates. [**Shop fabricate interior and exterior corners.**]

1. Joint Style: Overlapped, 4 inches (100 mm) wide Butted with expansion space and 6-inch- (150-mm-) wide, concealed backup plate Butted with expansion space and 6-inch- (150-mm-) wide, exposed cover plate Insert description.
2. Fabricate with scuppers spaced [10 ft. (3 m)] <Insert dimension> apart, to dimensions required with 4-inch- (100-mm-) wide flanges and base extending 4 inches (100 mm) beyond cant or tapered strip into field of roof. Fasten gravel guard angles to base of scupper.
3. Fabricate from the following materials:
 - a. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - c. Aluminum: [0.050 inch (1.27 mm)] <Insert dimension> thick.
 - d. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 - e. Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - f. Zinc-Tin Alloy-Coated Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - g. Zinc: 0.048 inch (1.25 mm) 0.059 inch (1.50 mm) Insert dimension thick.
 - h. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.

B. Copings: Fabricate in minimum 96-inch- (2400-mm-) long, but not exceeding 12 ft.- (3.6 m) long, sections. Fabricate joint plates of same thickness as copings. Furnish with continuous cleats to support edge of external leg and drill elongated holes for fasteners on interior leg. Miter corners, fasten and seal solder or weld watertight. Shop fabricate interior and exterior corners.

1. Coping Profile: Fig. 3-4A Fig. 3-4B Fig. 3-4C Fig. 3-4D Fig. 3-4E Fig. 3-4F Fig. 3-4G in accordance with SMACNA's "Architectural Sheet Metal Manual."
2. Joint Style: Butted with expansion space and 6-inch- (150-mm-) wide, concealed backup plate Butted with expansion space and 6-inch- (150-mm-) wide, exposed cover plate Insert description.
3. Fabricate from the following materials:
 - a. Galvanized Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - b. Aluminum-Zinc Alloy-Coated Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - c. Aluminum: [0.050 inch (1.27 mm)] <Insert dimension> thick.
 - d. Stainless Steel: [0.0250 inch (0.635 mm)] <Insert dimension> thick.

- e. Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 - f. Zinc-Tin Alloy-Coated Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 - g. Zinc: 0.048 inch (1.25 mm) 0.059 inch (1.50 mm) Insert dimension thick.
 - h. Copper-Clad Stainless Steel: [0.027 inch (0.69 mm)] <Insert dimension> thick.
- C. Expansion-Joint Cover: Shop fabricate interior and exterior corners. Fabricate roof roof-to-wall transition roof-to-roof edge-flashing (gravel-stop) transition roof-to-roof edge-flashing (gravel-stop) and fascia-cap transition expansion-joint cover from the following materials:
- 1. Galvanized Steel: [0.034 inch (0.86 mm)] <Insert dimension> thick.
 - 2. Aluminum-Zinc Alloy-Coated Steel: [0.034 inch (0.86 mm)] <Insert dimension> thick.
 - 3. Aluminum: [0.050 inch (1.27 mm)] <Insert dimension> thick.
 - 4. Stainless Steel: [0.0250 inch (0.635 mm)] <Insert dimension> thick.
 - 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - 8. Copper-Clad Stainless Steel: [0.027 inch (0.69 mm)] <Insert dimension> thick.
- D. Base Flashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
- 1. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - 2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 - 3. Aluminum: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 - 4. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 - 5. Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - 6. Zinc-Tin Alloy-Coated Copper: [20 oz./sq. ft. (0.68 mm thick)] <Insert value>.
 - 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - 8. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.
- E. Counterflashing: Shop fabricate interior and exterior corners. Fabricate from the following materials:
- 1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 - 2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 - 3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
 - 4. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 - 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - 8. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.
- F. Flashing Receivers: Fabricate from the following materials:
- 1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 - 2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 - 3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
 - 4. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
 - 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 - 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 - 8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.
- G. Roof-Penetration Flashing: Fabricate from the following materials:

1. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
3. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
4. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
5. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
6. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
7. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.
8. Lead: [4 lb (1.8 kg)] <Insert weight>.

H. Roof-Drain Flashing: Fabricate from the following materials:

1. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
2. Copper: [12 oz./sq. ft. (0.41 mm thick)] <Insert value>.
3. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.

2.8 STEEP-SLOPE ROOF SHEET METAL FABRICATIONS

A. Apron, Step, Cricket, and Backer Flashing: Fabricate from the following materials:

1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
4. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.

B. Valley Flashing: Fabricate from the following materials:

1. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
3. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
4. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
5. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
6. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
7. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.

C. Drip Edges: Fabricate from the following materials:

1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
4. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.

D. Eave, Rake, Ridge, and Hip Flashing: Fabricate from the following materials:

1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
4. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.

5. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] **<Insert dimension>** thick.

E. Counterflashing: **[Shop fabricate interior and exterior corners.]** Fabricate from the following materials:

1. Galvanized Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
3. Aluminum: [0.032 inch (0.81 mm)] **<Insert dimension>** thick.
4. Stainless Steel: [0.0188 inch (0.477 mm)] **<Insert dimension>** thick.
5. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] **<Insert dimension>** thick.

F. Flashing Receivers: Fabricate from the following materials:

1. Galvanized Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] **<Insert dimension>** thick.
3. Aluminum: [0.032 inch (0.81 mm)] **<Insert dimension>** thick.
4. Stainless Steel: [0.0156 inch (0.396 mm)] **<Insert dimension>** thick.
5. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] **<Insert dimension>** thick.

G. Roof-Penetration Flashing: Fabricate from the following materials:

1. Galvanized Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] **<Insert dimension>** thick.
3. Stainless Steel: [0.0188 inch (0.477 mm)] **<Insert dimension>** thick.
4. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
5. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
6. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
7. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] **<Insert dimension>** thick.
8. Lead: [4 lb (1.8 kg)] **<Insert weight>**.

2.9 WALL SHEET METAL FABRICATIONS

A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- (2400-mm-) long, but not exceeding 12 ft. (3.6 m) long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches (150 mm) beyond each side of wall openings; and form with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:

1. Stainless Steel: [0.0156 inch (0.396 mm)] **<Insert dimension>** thick.
2. Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
3. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] **<Insert value>**.
4. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
5. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] **<Insert dimension>** thick.

- B. Opening Flashings in Frame Construction: Fabricate head, sill, [jamb,] and similar flashings to extend [4 inches (100 mm)] <Insert dimension> beyond wall openings. Form head and sill flashing with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:
1. Galvanized Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.022 inch (0.56 mm)] <Insert dimension> thick.
 3. Aluminum: [0.032 inch (0.81 mm)] <Insert dimension> thick.
 4. Stainless Steel: [0.0156 inch (0.396 mm)] <Insert dimension> thick.
 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 8. Copper-Clad Stainless Steel: [0.016 inch (0.40 mm)] <Insert dimension> thick.
- C. Wall Expansion-Joint Cover: Fabricate from the following materials:
1. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 3. Aluminum: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 4. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 5. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 6. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 7. Zinc: 0.032 inch (0.80 mm) 0.039 inch (1.00 mm) Insert dimension thick.
 8. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.

2.10 MISCELLANEOUS SHEET METAL FABRICATIONS

- A. Equipment Support Flashing: Fabricate from the following materials:
1. Galvanized Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.028 inch (0.71 mm)] <Insert dimension> thick.
 3. Stainless Steel: [0.0188 inch (0.477 mm)] <Insert dimension> thick.
 4. Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 5. Zinc-Tin Alloy-Coated Copper: [16 oz./sq. ft. (0.55 mm thick)] <Insert value>.
 6. Copper-Clad Stainless Steel: [0.018 inch (0.46 mm)] <Insert dimension> thick.
- B. Overhead-Piping Safety Pans: Fabricate from the following materials:
1. Galvanized Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 2. Aluminum-Zinc Alloy-Coated Steel: [0.040 inch (1.02 mm)] <Insert dimension> thick.
 3. Stainless Steel: [0.0250 inch (0.635 mm)] <Insert dimension> thick.
 4. Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 5. Zinc-Tin Alloy-Coated Copper: [24 oz./sq. ft. (0.82 mm thick)] <Insert value>.
 6. Copper-Clad Stainless Steel: [0.027 inch (0.69 mm)] <Insert dimension> thick.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrates, and other conditions affecting performance of the Work.
1. Verify compliance with requirements for installation tolerances of substrates.

2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
3. Verify that air- or water-resistant barriers have been installed over substrate to prevent air infiltration or water penetration.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF UNDERLAYMENT

- A. Synthetic Underlayment: Install synthetic underlayment, wrinkle free, in accordance with manufacturers' written instructions, and using adhesive where possible to minimize use of mechanical fasteners under sheet metal.
1. Lap horizontal joints not less than 4 inches (100 mm).
 2. Lap end joints not less than 12 inches (300 mm).
- B. Self-Adhering, High-Temperature Sheet Underlayment:
1. Install self-adhering, high-temperature sheet underlayment; wrinkle free.
 2. Prime substrate if recommended by underlayment manufacturer.
 3. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures.
 4. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses.
 5. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps and edges with roller.
 6. Roll laps and edges with roller.
 7. Cover underlayment within 14 days.
- C. Felt Underlayment: Install felt underlayment, wrinkle free, using adhesive to minimize use of mechanical fasteners under sheet metal flashing and trim.
1. Install in shingle fashion to shed water.
 2. Lap joints not less than 2 inches (50 mm).
- D. Install slip sheet, wrinkle free, ~~over underlayment~~ **[directly on substrate]** <Insert requirement> before installing sheet metal flashing and trim.
1. Install in shingle fashion to shed water.
 2. Lapp joints not less than 4 inches (100 mm).

3.3 INSTALLATION OF SHEET METAL FLASHING AND TRIM, GENERAL

- A. Install sheet metal flashing and trim to comply with details indicated and recommendations of cited sheet metal standard that apply to installation characteristics required unless otherwise indicated on Drawings.
1. Install fasteners[, **solder**], protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
 2. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of [**solder**] [**welds**] [**sealant**].
 3. Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement.
 4. Install sheet metal flashing and trim to fit substrates and to result in watertight performance.
 5. Install continuous cleats with fasteners spaced not more than 12 inches (300 mm) o.c.

6. Space individual cleats not more than 12 inches (300 mm) apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
 7. Install exposed sheet metal flashing and trim with limited oil-canning, and free of buckling and tool marks.
 8. Do not field cut sheet metal flashing and trim by torch.
 9. Do not use graphite pencils to mark metal surfaces.
- B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.
1. Coat concealed side of **[uncoated-aluminum] [and] [stainless steel]** sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
 2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.
- C. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim.
1. Space movement joints at maximum of [10 ft. (3 m)] **<Insert dimension>** with no joints within 24 inches (600 mm) of corner or intersection.
 2. Form expansion joints of intermeshing hooked flanges, not less than 1 inch (25 mm) deep, filled with sealant concealed within joints.
 3. Use lapped expansion joints only where indicated on Drawings.
- D. Fasteners: Use fastener sizes that penetrate **[wood blocking or sheathing not less than 1-1/4 inches (32 mm) for nails and not less than 3/4 inch (19 mm) for wood screws]** **[substrate not less than recommended by fastener manufacturer to achieve maximum pull-out resistance]** **<Insert size requirement>**.
- E. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.
- F. Seal joints as required for watertight construction.
1. Use sealant-filled joints unless otherwise indicated.
 - a. Embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant.
 - b. Form joints to completely conceal sealant.
 - c. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way.
 - d. Adjust setting proportionately for installation at higher ambient temperatures.
 - 1) Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).
 2. Prepare joints and apply sealants to comply with requirements in Section 07 9200 "Joint Sealants."
- G. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter.
1. Pretin edges of sheets with solder to width of 1-1/2 inches (38 mm); however, reduce pretinning where pretinned surface would show in completed Work.
 2. Do not solder **[metallic-coated steel] [and] [aluminum]** sheet.
 3. Do not pretin zinc-tin alloy-coated copper.
 4. Do not use torches for soldering.
 5. Heat surfaces to receive solder, and flow solder into joint.

- a. Fill joint completely.
- b. Completely remove flux and spatter from exposed surfaces.
- 6. Stainless Steel Soldering:
 - a. Tin edges of uncoated sheets, using solder for stainless steel and acid flux.
 - b. Promptly remove acid-flux residue from metal after tinning and soldering.
 - c. Comply with solder manufacturer's recommended methods for cleaning and neutralization.
- 7. Copper Soldering: Tin edges of uncoated sheets, using solder for copper.
- 8. Copper-Clad Stainless Steel Soldering: Tin edges of uncoated sheets, using solder for copper-clad stainless steel.

H. Rivets: Rivet joints in **[uncoated aluminum]** **[zinc]** where necessary for strength.

3.4 INSTALLATION OF ROOF-DRAINAGE SHEET METAL FABRICATIONS

- A. Install sheet metal roof-drainage items to produce complete roof-drainage system in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of roof perimeter flashing with installation of roof-drainage system.
- B. Hanging Gutters:
 - 1. Join sections with **[riveted and soldered joints]** **[or]** **[joints sealed with sealant]**.
 - 2. Provide for thermal expansion.
 - 3. Attach gutters at eave or fascia to firmly anchor them in position.
 - 4. Provide end closures and seal watertight with sealant.
 - 5. Slope to downspouts.
 - 6. Fasten gutter spacers to front and back of gutter.
 - 7. Anchor and loosely lock back edge of gutter to continuous **[cleat]** **[eave or apron flashing]**.
 - 8. Anchor back of gutter that extends onto roof deck with cleats spaced not more than [24 inches (600 mm)] **<Insert dimension>** apart.
 - 9. Anchor gutter with **[gutter brackets]** **[straps]** **[twisted straps]** spaced not more than [24 inches (600 mm)] [30 inches (760 mm)] [36 inches (910 mm)] **<Insert dimension>** apart to roof deck unless otherwise indicated, and loosely lock to front gutter bead.
 - 10. Anchor gutter with spikes and ferrules spaced not more than [24 inches (600 mm)] [30 inches (760 mm)] **<Insert dimension>** apart.
 - 11. Install gutter with expansion joints at locations indicated on Drawings, but not exceeding, [50 ft. (15.2 m)] **<Insert dimension>** apart. Install expansion-joint caps.
 - 12. Install continuous gutter screens on gutters with noncorrosive fasteners, **[removable]** **[hinged to swing open]** for cleaning gutters.
- C. Built-in Gutters:
 - 1. Join sections with **[riveted and soldered joints]** **[or]** **[joints sealed with sealant]**.
 - 2. Provide for thermal expansion.
 - 3. Slope to downspouts.
 - 4. Provide end closures and seal watertight with sealant.
 - 5. Install underlayment layer in built-in gutter trough and extend to drip edge at eaves and under underlayment on roof sheathing.
 - a. Lap sides minimum of 2 inches (50 mm) over underlying course.
 - b. Lap ends minimum of 4 inches (100 mm).
 - c. Stagger end laps between succeeding courses at least 72 inches (1830 mm).
 - d. Fasten with roofing nails.

- e. Install slip sheet over underlayment.
 - 6. Anchor and loosely lock back edge of gutter to continuous [**cleat**] [**eave or apron flashing**].
 - 7. Anchor back of gutter that extends onto roof deck with cleats spaced not more than [18 inches (460 mm)] <**Insert dimension**> apart.
 - 8. Install gutter with expansion joints at locations indicated on Drawings, but not exceeding, [50 ft. (15.2 m)] <**Insert dimension**> apart. Install expansion-joint caps.
 - D. Downspouts:
 - 1. Join sections with 1-1/2-inch (38-mm) telescoping joints.
 - 2. Provide hangers with fasteners designed to hold downspouts securely to walls.
 - 3. Locate hangers at top and bottom and at approximately 60 inches (1500 mm) o.c.
 - 4. Provide elbows at base of downspout to direct water away from building.
 - 5. Connect downspouts to underground drainage system.
 - E. Splash Pans:
 - 1. Install where downspouts discharge on [**low-slope roofs**] <**Insert surface**>.
 - 2. Set in [**asphalt roofing cement**] [**or**] [**elastomeric sealant**] compatible with the substrate.
 - F. Parapet Scuppers:
 - 1. Continuously support scupper, set to correct elevation, and seal flanges to interior wall face, over cants or tapered edge strips, and under roofing membrane.
 - 2. Anchor scupper closure trim flange to exterior wall and [**solder**] [**or**] [**seal with elastomeric sealant**] to scupper.
 - 3. Loosely lock front edge of scupper with conductor head.
 - 4. [**Solder**] [**or**] [**seal with elastomeric sealant**] exterior wall scupper flanges into back of conductor head.
 - G. Conductor Heads: Anchor securely to wall, with elevation of conductor head rim at minimum of 1 inch (25 mm) below [**scupper**] [**or**] [**gutter**] discharge.
 - H. Expansion-Joint Covers: Install expansion-joint covers at locations and of configuration indicated on Drawings. Lap joints minimum of 4 inches (100 mm) in direction of water flow.
- 3.5 INSTALLATION OF SLOPED ROOF SHEET METAL FABRICATIONS

- A. Install sheet metal flashing and trim to comply with performance requirements[, **sheet metal manufacturer's written installation instructions**,] and cited sheet metal standard.
 - 1. Provide concealed fasteners where possible, and set units true to line, levels, and slopes.
 - 2. Install work with laps, joints, and seams that are permanently watertight and weather resistant.
- B. Roof Edge Flashing:
 - 1. Install roof edge flashings in accordance with ANSI/SPRI/FM 4435/ES-1.
 - 2. Anchor to resist uplift and outward forces in accordance with recommendations in cited sheet metal standard unless otherwise indicated. Interlock bottom edge of roof edge flashing with continuous cleat anchored to substrate at [**staggered 3-inch (75-mm)**] <**Insert spacing**> centers.

3. Anchor to resist uplift and outward forces in accordance with recommendations in FM Global Property Loss Prevention Data Sheet 1-49 for FM Approvals' listing for required windstorm classification.
- C. Copings:
1. Install copings in accordance with ANSI/SPRI/FM 4435/ES-1.
 2. Anchor to resist uplift and outward forces in accordance with recommendations in cited sheet metal standard unless otherwise indicated.
 - a. Interlock exterior bottom edge of coping with continuous cleat anchored to substrate at [24-inch (600-mm)] [16-inch (400-mm)] **<Insert dimension>** centers.
 - b. Anchor interior leg of coping with washers and screw fasteners through slotted holes at [24-inch (600-mm)] **<Insert dimension>** centers.
 3. Anchor to resist uplift and outward forces in accordance with recommendations in FM Global Property Loss Prevention Data Sheet 1-49 for specified FM Approvals' listing for required windstorm classification.
- D. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches (100 mm) over base flashing. Install stainless steel draw band and tighten.
- E. Counterflashing: Coordinate installation of counterflashing with installation of base flashing.
1. Insert counterflashing in reglets or receivers and fit tightly to base flashing.
 2. Extend counterflashing 4 inches (100 mm) over base flashing.
 3. Lap counterflashing joints minimum of 4 inches (100 mm).
 4. Secure in waterproof manner by means of [**snap in installation and sealant or lead wedges and sealant**] [**interlocking folded seam or blind rivets and sealant**] [**anchor and washer spaced at 12 inches (300 mm) o.c. along perimeter and 6 inches (150 mm) o.c. at corners areas**] **<Insert requirement>** unless otherwise indicated.
- F. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric butyl sealant and clamp flashing to pipes that penetrate roof.
- 3.6 INSTALLATION OF WALL SHEET METAL FABRICATIONS
- A. Install sheet metal wall flashing to intercept and exclude penetrating moisture in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.
- B. Opening Flashings in Frame Construction: Install continuous head, sill, [**jamb,**] and similar flashings to extend [4 inches (100 mm)] **<Insert dimension>** beyond wall openings.
- C. Reglets: Installation of reglets is specified in [**Section 03 3000 "Cast-in-Place Concrete."**] [**Section 04 2000 "Unit Masonry."**] [**Section <Insert Section number> "<Insert Section title>."**]
- 3.7 INSTALLATION OF MISCELLANEOUS SHEET METAL FABRICATIONS
- A. Equipment Support Flashing:
1. Coordinate installation of equipment support flashing with installation of roofing and equipment.

2. Weld or seal flashing with elastomeric sealant to equipment support member.

B. Overhead-Piping Safety Pans:

1. Suspend pans from structure above, independent of other overhead items such as equipment, piping, and conduit, unless otherwise indicated on Drawings.
2. Pipe and install drain line to plumbing waste or drainage system.

3.8 INSTALLATION TOLERANCES

- A. Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

3.9 CLEANING

- A. Clean and neutralize flux materials. Clean off excess solder.
- B. Clean off excess sealants.

3.10 PROTECTION

- A. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.
- B. On completion of sheet metal flashing and trim installation, remove unused materials and clean finished surfaces as recommended in writing by sheet metal flashing and trim manufacturer.
- C. Maintain sheet metal flashing and trim in clean condition during construction.
- D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures, as determined by Architect.

END OF SECTION

SECTION 07 7253 - SNOW GUARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pad-type, flat-mounted metal snow guards.
 - 2. Rail-type, flat-mounted snow guards.
 - 3. Rail-type, seam-mounted snow guards.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product, include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Shop Drawings: Include roof plans showing layouts and attachment details of snow guards.
 - 1. Include details of rail-type snow guards.
- C. Samples:
 - 1. Pad-Type Snow Guards: Full-size unit with installation hardware.
 - a. For units with factory-applied finishes, submit specified color.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer's experience with providing delegated design engineering services of the kind indicated, including documentation that the engineer is licensed in the **[jurisdiction]** **[state]** in which the Project is located.

1.4 QUALITY ASSURANCE

- A. Provide the following upon request:
 - 1. Product Test Reports: For each type of snow guard, for tests performed by a qualified testing agency, indicating load at failure of attachment to roof system identical to roof system used on this Project.

1.5 FIELD CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit adhesive-mounted snow guards to be installed, and adhesive cured, in accordance with adhesive manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Performance Requirements: Provide snow guards that withstand exposure to weather and resist thermally induced movement without failure, rattling, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- B. Structural Performance: Snow guards shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated.
 - 1. Snow Loads: As indicated on Drawings.

2.2 PAD-TYPE SNOW GUARDS

- A. Pad-Type, Flat-Mounted Metal Snow Guards:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Alpine SnowGuards, a division of Vermont Slate & Copper Services, Inc.
 - b. Berger Building Products, Inc.
 - c. IceBlox Inc.
 - d. Rocky Mountain Snow Guards, Inc.
 - e. Sieger Snow Guards Inc.
 - f. TRA SNOW AND SUN, INC.
 - g. Zaleski Snow-Guard and Roofing Specialties Inc.
 - 2. Material:
 - a. ASTM B370 copper sheet, not less than 16 oz./sq. ft. (0.55 mm thick).
 - 3. Attachment: Manufacturer's tested system, capable of resisting design loads.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances, snow guard attachment, and other conditions affecting performance of the Work.
 - 1. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and prepare substrates for bonding snow guards.
- B. Prime substrates in accordance with snow guard manufacturer's written instructions.

3.3 INSTALLATION

- A. Install snow guards in accordance with manufacturer's written instructions.
 - 1. Space rows as indicated on Drawings.
 - 2. Space rows as recommended by manufacturer.
- B. Attachment for Batten-Seam Metal Roofing:
 - 1. Install per manufacturer's instructions.

END OF SECTION

FOR REFERENCE ONLY

SECTION 07 9200 - JOINT SEALANTS**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Silicone joint sealants.
2. Weather barrier sealants.
3. Urethane joint sealants.
4. Latex joint sealants.
5. Butyl rubber joint sealants.
6. Mildew-resistant joint sealants.

B. Related Requirements:

1. Section 04 2000 "Unit Masonry" for masonry control and expansion joint fillers and gaskets.
2. Section 07 9100 "Preformed Joint Seals" for **[preformed, foam joint seals] precured, extruded-silicone joint seals**.
3. Section 07 9219 "Acoustical Joint Sealants" for acoustical sealants used in sound rated partitions.
4. Sections 079513.13 "Interior Expansion Joint Cover Assemblies," 079513.16 "Exterior Expansion Joint Cover Assemblies," and 079513.19 "Parking Deck Expansion Joint Cover Assemblies" for building expansion joints.
5. Section 07 8443 "Joint Firestopping" for sealing joints in fire-resistance-rated construction.
6. Section 08 4400 "Glazed Curtain Walls" for structural and other glazing sealants used in curtain wall assemblies.
7. Section 08 8000 "Glazing" for glazing sealants.
8. Section 08 8400 "Plastic Glazing" for plastic glazing sealants.
9. Section 09 2613 "Gypsum Veneer Plastering" for sealing perimeter joints and penetrations.
10. Section 09 2900 "Gypsum Board" for sealing perimeter joints and penetrations.
11. Section 09 3000 "Tiling" for sealing tile joints and penetrations.
12. Section 09 5113 "Acoustical Panel Ceilings" Section 09 5123 "Acoustical Tile Ceilings" for sealing edge moldings at perimeters with acoustical sealant.
13. Section 09 6313.35 "Chemical-Resistant Brick Flooring" for sealing flooring joints.
14. Section 32 1373 "Concrete Paving Joint Sealants" for sealing joints in pavements, walkways, and curbing.

1.2 PRECONSTRUCTION TESTING**A. Preconstruction Compatibility and Adhesion Testing:** Submit to joint-sealant manufacturers, for testing indicated below, samples of materials that will contact or affect joint sealants.

1. Use **[ASTM C 1087] [manufacturer's standard test method]** to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
2. Submit not fewer than **[eight] <Insert number>** pieces of each kind of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.

3. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
4. For materials failing tests, obtain joint-sealant manufacturer's written instructions for corrective measures including use of specially formulated primers.
5. Testing will not be required if joint-sealant manufacturers submit joint preparation data that are based on previous testing, not older than 24 months, of sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.

B. Preconstruction Field-Adhesion Testing: Before installing sealants, field test their adhesion to Project joint substrates as follows:

1. Locate test joints where indicated on Project or, if not indicated, as directed by Architect.
2. Conduct field tests for each application indicated below:
 - a. Each kind of sealant and joint substrate indicated.
3. Notify Architect seven days in advance of dates and times when test joints will be erected.
4. Arrange for tests to take place with joint-sealant manufacturer's technical representative present.
 - a. Test Method: Test joint sealants in accordance with Method A, Field Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - 1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
5. Report whether sealant failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. For sealants that fail adhesively, retest until satisfactory adhesion is obtained.
6. Evaluation of Preconstruction Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants that fail to adhere to joint substrates during testing.

1.3 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 01 3300 "Submittal Procedures" Section 07 0413 "Common Submittal Requirements for Thermal and Moisture Protection".
- B. Product Data: For each joint-sealant product indicated.
- C. Sustainable Design Submittals:
 1. Product Data: For sealants, indicating VOC content.
 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials
- D. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.
- E. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

- F. Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

- A. Preconstruction Compatibility and Adhesion Test Reports: From sealant manufacturer, indicating the following:
 - 1. Materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.
 - 2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.
- B. Preconstruction Field-Adhesion Test Reports: Indicate which sealants and joint preparation methods resulted in optimum adhesion to joint substrates based on testing specified in "Preconstruction Testing" Article.
- C. Field-Adhesion Test Reports: For each sealant application tested.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Source Limitations: Obtain each kind of joint sealant from single source from single manufacturer.
- C. Product Testing: Test joint sealants using a qualified testing agency.
 - 1. Testing Agency Qualifications: An independent testing agency qualified in accordance with ASTM C 1021 to conduct the testing indicated.
 - 2. Test in accordance with SWRI's Sealant Validation Program for compliance with requirements specified by reference to ASTM C 920 for adhesion and cohesion under cyclic movement, adhesion-in-peel, and indentation hardness.
- D. Provide the following upon request:
 - 1. Qualification Data: For qualified [**Installer**] [and] [**testing agency**].
 - 2. Product Certificates: For each kind of joint sealant and accessory, from manufacturer.
 - 3. Sealant, Waterproofing, and Restoration Institute (SWRI) Validation Certificate: For each sealant specified to be validated by SWRI's Sealant Validation Program.
 - 4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, indicating that sealants comply with requirements.
- E. Mockups: Install sealant in mockups of assemblies specified in other Sections that are indicated to receive joint sealants specified in this Section. Use materials and installation methods specified in this Section.
- F. Preinstallation Conference: Conduct conference at Project site.

1.6 PROJECT CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer[**or are below** 40 deg F (5 deg C)].
 2. When joint substrates are wet.
 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.7 WARRANTY

- A. Special Installer's Warranty: Manufacturer's standard form in which Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
1. Warranty Period: [**Five**] <Insert number> years from date of Substantial Completion.
- B. Special Manufacturer's Warranty: Manufacturer's standard form in which joint-sealant manufacturer agrees to furnish joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.
1. Warranty Period: < **Insert number** > years from date of Substantial Completion.
- C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:
1. Movement of the structure caused by structural settlement or errors attributable to design or construction resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
 2. Disintegration of joint substrates from natural causes exceeding design specifications.
 3. Mechanical damage caused by individuals, tools, or other outside agents.
 4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.
- B. VOC Content: Verify sealants and sealant primers comply with the following:
1. Architectural sealant shall have a VOC content of 250 g/L or less.
 2. Sealants and sealant primers for nonporous substrates have a VOC content of 250 g/L or less.
 3. Sealants and sealant primers for porous substrates have a VOC content of 775 g/L or less.
 4. Verify sealant complies with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

- C. Liquid-Applied Joint Sealants: Comply with ASTM C 920 and other requirements indicated for each liquid-applied joint sealant specified, including those referencing ASTM C 920 classifications for type, grade, class, and uses related to exposure and joint substrates.
1. Suitability for Immersion in Liquids. Where sealants are indicated for Use I for joints that will be continuously immersed in liquids, provide products that have undergone testing in accordance with ASTM C 1247. Liquid used for testing sealants is deionized water, unless otherwise indicated.
- D. Stain-Test-Response Characteristics: Where sealants are specified to be nonstaining to porous substrates, provide products that have undergone testing in accordance with ASTM C 1248 and have not stained porous joint substrates indicated for Project.
- E. Suitability for Contact with Food: Where sealants are indicated for joints that will come in repeated contact with food, provide products that comply with 21 CFR 177.2600.
- F. Colors of Exposed Joint Sealants: [**As indicated by manufacturer's designations**] [**Match Architect's samples**] [**As selected by Architect from manufacturer's full range**].

2.2 SILICONE JOINT SEALANTS

- A. Sealant JS-S1 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 50, for Use NT.
1. Products: Subject to compliance with requirements, provide products from the following table that has a validation certificate from the Sealant, Waterproofing and Restoration Institute (SWRI).

Manufacturer	Product	Manufacturer Rated Movement Capability (CLASS)	Substrate Primer Required: Yes/No/Test			
			Morta r*	Anod. Alum.	Uncoated Glass	Other*
Dow Inc.	Dowsil 791	± 50%	Yes	Test	No	Test
Dow Inc.	Dowsil 795	± 50%	No	Yes	No	Test
Dow Inc.	Dowsil 756 SMS	± 50%	No	Yes	No	Test
Momentive Performance Materials, Inc.	Silpruf SCS2000	± 50%	Yes	Test	No	Test
Momentive Performance Materials, Inc.	SCS9000 Silpruf NB	± 50%	Yes	Test	No	Test
Pecora Corporation	864	± 50%	Yes	Test	No	Test
Pecora Corporation	895	± 50%	Yes	Test	No	Test
Tremco Incorporated	Spectrem 3	± 50%	Yes	Test	No	Test
Tremco Incorporated	Spectrem 4-TS	± 50%	Yes	Test	No	Test

Table Notes:

* Indicates substrates with a cement component, such as concrete, that require use of a primer.

** Indicates that other substrates shall be tested for adhesion to determine if a primer will be required.

- B. Sealant JS-S2 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 100/50, for Use NT.

1. Products: Subject to compliance with requirements, provide products from the following table that has a validation certificate from the Sealant, Waterproofing and Restoration Institute (SWRI).

Manufacturer	Product	Manufacturer Rated Movement Capability (CLASS)	Substrate Primer Required: Yes/No/Test			
			Morta r*	Anod. Alum.	Uncoated Glass	Other*
Dow Inc.	Dowsil 790	+ 100/- 50%	No	Yes	No	Test
Momentive Performance Materials, Inc.	SCS2700 Silpruf LM	+ 100/- 50%	Yes	Test	No	Test
Pecora Corporation	890	+ 100/- 50%	Yes	Test	No	Test
Tremco Incorporated	Spectrem 1	+ 100/- 50%	Yes	Test	No	Test

Table Notes:

* Indicates substrates with a cement component, such as concrete, that require use of a primer.

** Indicates that other substrates shall be tested for adhesion to determine if a primer will be required.

2.3 WEATHER BARRIER SEALANTS

- A. Sealant JS-W1 - Single-Component, Nonsag, Neutral-Curing Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT; tested and marketed specifically for sealing air barrier and vapor retarder sheets to common building materials, such as aluminum, vinyl, PVC, powder coat, paint and fluoropolymer coatings; UV resistant..

1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
- a. Dow Corp.; Dowsil 758.

2.4 URETHANE JOINT SEALANTS

- A. Sealant JS-U1 - Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant: ASTM C 920. Type M, Grade P, Class 25, for Use T and I.

1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. LymTal International, Inc.; Iso-Flex 880 GB.
 - b. Sika Corporation; Sikaflex-2c SL.
 - c. Tremco Incorporated; Vulkem 445SSL.
- B. Sealant JS-U2 - Multicomponent, Nonsag, Traffic-Grade, Urethane Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
 1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. Master Builders Solutions; MasterSeal NP 2.
 - b. LymTal International, Inc.; [**Iso-Flex 881**] [**or**] [**Iso-Flex 885 SG**].
 - c. Pacific Polymers International, Inc.; [**Elasto-Thane 227 High Shore Type II**] [**or**] [**Elasto-Thane 227 Type II**].
 - d. Pecora Corporation; DynaTred.
 - e. Sika Corporation, Construction Products Division; [**Sikaflex-2c NS**] [**or**] [**Sikaflex-2c EZ Mix**].
 - f. Tremco Incorporated; Vulkem 116 + catalyst.

2.5 LATEX JOINT SEALANTS

- A. Sealant JS-L1 - Latex Joint Sealant: Acrylic latex or siliconized acrylic latex, ASTM C 834.
 1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. Bostik, Inc.; Chem-Calk 600.
 - b. DAP Products Inc.; Dynaflex 230.
 - c. Pecora Corporation; AC-20 + Silicone.
 - d. Schnee-Morehead, Inc.; Acryl-R SM8200.
 - e. Tremco Incorporated; Tremflex 834.

2.6 BUTYL RUBBER JOINT SEALANTS

- A. Sealant JS-B1 - Butyl-Rubber-Based Joint Sealant: ASTM C 1311.
 1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. Bostik, Inc.; Chem-Calk 300.
 - b. Pecora Corporation; BC-158.
 - c. Tremco Incorporated; Tremco Butyl Sealant.

2.7 MILDEW-RESISTANT JOINT SEALANTS

- A. Sealant JS-M1 - Mildew-Resistant, Single-Component, Silicone Joint Sealant: ASTM C 920, Type S, Grade NS, Class 25, for Use NT.
 1. Products: Subject to compliance with requirements, [**provide the following**] [**provide one of the following**] [**available products that may be incorporated into the Work include, but are not limited to, the following**]:
 - a. Dow Inc.; Dowsil 786 Silicone Sealant.

- b. GE Silicones; SCS1700 Sanitary.
- c. Pecora Corporation; 898NST.
- d. Tremco Incorporated; Tremsil 200.

2.8 JOINT SEALANT BACKING

- A. General: Provide sealant backings of material that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.
- B. Cylindrical Sealant Backings: ASTM C 1330, [**Type C (closed-cell material with a surface skin)**] [**Type O (open-cell material)**] [**Type B (bicellular material with a surface skin)**] [**or any of the preceding types, as approved in writing by joint-sealant manufacturer for joint application indicated**], and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.
- C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.9 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
 - a. Concrete.
 - b. Masonry.
 - c. Unglazed surfaces of ceramic tile.
 - d. Exterior insulation and finish systems.
 - e. **<Insert other porous joint substrate>.**
 3. Remove laitance and form-release agents from concrete.
 4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:
 - a. Metal.
 - b. Glass.
 - c. Porcelain enamel.
 - d. Glazed surfaces of ceramic tile.
 - e. **<Insert other nonporous joint substrate>.**
- B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.
- ### 3.3 INSTALLATION OF JOINT SEALANTS
- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Do not extend exterior sealants and primers into building interior (that is, inside the weatherproofing system) unless first verifying compliance with VOC requirements.
- D. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
1. Do not leave gaps between ends of sealant backings.
 2. Do not stretch, twist, puncture, or tear sealant backings.

3. Remove absorbent sealant backings that have become wet before sealant application and replace them with dry materials.
- E. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- F. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 1. Place sealants so they directly contact and fully wet joint substrates.
 2. Completely fill recesses in each joint configuration.
 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- G. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 1. Remove excess sealant from surfaces adjacent to joints.
 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces. Water-based tooling agents are unacceptable.
 3. Provide concave joint profile per Figure 8A in ASTM C 1193, unless otherwise indicated.
 4. Provide flush joint profile where indicated per Figure 8B in ASTM C 1193.
 5. Provide recessed joint configuration of recess depth and at locations indicated per Figure 8C in ASTM C 1193.
 - a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

3.4 FIELD QUALITY CONTROL

- A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:
 1. Extent of Testing: Test completed and cured sealant joints as follows:
 - a. Perform [10] <Insert number> tests for the first [1000 feet (300 m)] <Insert dimension> of joint length for each kind of sealant and joint substrate.
 - b. Perform 1 test for each [1000 feet (300 m)] <Insert dimension> of joint length thereafter or 1 test per each floor per elevation.
 2. Test Method: Test joint sealants in accordance with Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
 - a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.
 3. Inspect tested joints and report on the following:
 - a. Whether sealants filled joint cavities and are free of voids.
 - b. Whether sealant dimensions and configurations comply with specified requirements.
 - c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion passes sealant manufacturer's field-adhesion hand-pull test criteria.

4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant fill, sealant configuration, and sealant dimensions.
5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

- B. Evaluation of Field-Adhesion Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.5 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.6 PROTECTION

- A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.7 JOINT-SEALANT SCHEDULE

- A. Joint-Sealant Application: Exterior joints in horizontal traffic surfaces; Type JS-U1JS-U2.

1. Joint Locations:
 - a. Control and expansion joints in brick pavers.
 - b. Isolation and contraction joints in cast-in-place concrete slabs.
 - c. Joints between plant-precast architectural concrete paving units.
 - d. Joints in stone paving units[, **including steps**].
 - e. Tile control and expansion joints.
 - f. Joints between different materials listed above.
 - g. **<Insert other joints>**.
 - h. Other joints as indicated.
2. Joint-Sealant Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range of colors**] **<Insert color>**.

- B. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-S1 and.

1. Joint Locations:
 - a. Construction joints in cast-in-place concrete.
 - b. Joints between plant-precast architectural concrete units.
 - c. Control and expansion joints in unit masonry.
 - d. Joints in dimension stone cladding.

- e. Joints in glass unit masonry assemblies.
 - f. Joints in exterior insulation and finish systems.
 - g. Joints between metal panels.
 - h. Joints between different materials listed above.
 - i. Perimeter joints between materials listed above and frames of **[doors]** **[windows]** **[and]** **[louvers]**.
 - j. Control and expansion joints in **[ceilings]** **[and other]** **[overhead surfaces]**.
 - k. **<Insert other joints>**.
 - l. Other joints as indicated.
2. Joint-Sealant Color: **[As indicated by manufacturer's designations]** **[Match Architect's sample]** **[As selected by Architect from manufacturer's full range of colors]** **<Insert color>**.
- C. Joint-Sealant Application: Exterior weather barrier joints; Type JS-W1.
- D. Joint-Sealant Application: Interior joints in horizontal traffic surfaces; Type JS-U1 and.
- 1. Joint Locations:
 - a. Isolation joints in cast-in-place concrete slabs.
 - b. Control and expansion joints in stone flooring.
 - c. Control and expansion joints in brick flooring.
 - d. Control and expansion joints in tile flooring.
 - e. **<Insert other joints>**.
 - f. Other joints as indicated.
 - 2. Joint-Sealant Color: **[As indicated by manufacturer's designations]** **[Match Architect's sample]** **[As selected by Architect from manufacturer's full range of colors]** **<Insert color>**.
- E. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-L1 JS-B1.
- 1. Joint Locations:
 - a. Control and expansion joints on exposed interior surfaces of exterior walls.
 - b. Perimeter joints of exterior openings where indicated.
 - c. Tile control and expansion joints.
 - d. Vertical joints on exposed surfaces of **[interior unit masonry]** **[concrete]** **[walls]** **[and]** **[partitions]**.
 - e. Joints on underside of plant-precast structural concrete **[beams]** **[and]** **[planks]**.
 - f. Perimeter joints between interior wall surfaces and frames of **[interior doors]** **[windows]** **[and]** **[elevator entrances]**.
 - g. **<Insert other joints>**.
 - h. Other joints as indicated.
 - 2. Joint-Sealant Color: **[As indicated by manufacturer's designations]** **[Match Architect's sample]** **[As selected by Architect from manufacturer's full range of colors]** **<Insert color>**.
- F. Joint-Sealant Application: Mildew-resistant interior joints in vertical surfaces and horizontal nontraffic surfaces; Type JS-M1.
- 1. Joint Sealant Location:
 - a. Joints between plumbing fixtures and adjoining walls, floors, and counters.
 - b. Tile control and expansion joints where indicated.
 - c. **<Insert other joints>**.
 - d. Other joints as indicated.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

2. Joint-Sealant Color: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range of colors**] <Insert color>.

END OF SECTION

FOR REFERENCE ONLY

SECTION 07 9219 - ACOUSTICAL JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Acoustical joint sealants.
- B. Related Requirements:
 - 1. Section 07 9200 "Joint Sealants" joint sealants for nonacoustical applications.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: Manufacturer's color charts consisting of strips of cured sealants, showing full range of available colors for each product exposed to view.
- C. Samples for Verification: For each type and color of acoustical joint sealant required.
 - 1. Size: 1/2-inch- (13-mm-) wide sealant joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- D. Acoustical Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.

1.3 INFORMATIONAL SUBMITTALS

- A. Test and Evaluation Reports:
 - 1. Product Test Reports: For each type of acoustical joint sealant, for tests performed by manufacturer and witnessed by a qualified testing agency.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained between 40 and 95 deg F (4 and 35 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.5 FIELD CONDITIONS

- A. Apply coatings only when temperature of surfaces to be coated and ambient air temperatures are between 60 and 90 deg F (16 and 32 deg C).

1.6 WARRANTY

- A. Installer's Special Warranty: Installer agrees to repair or replace acoustical joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.
- B. Manufacturer's Special Warranty: Manufacturer agrees to furnish acoustical joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.
 1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ACOUSTICAL JOINT SEALANTS

- A. Acoustical joint-sealant products that effectively reduce airborne sound transmission through perimeter joints and openings in building construction, as demonstrated by testing representative assemblies in accordance with ASTM E90.
- B. Acoustical Sealant for Exposed and Concealed Joints: Manufacturer's standard nonsag, paintable, nonstaining latex acoustical sealant complying with ASTM C834.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. DAP Products Inc.
 - b. Everkem Diversified Products, Inc.
 - c. Franklin International.
 - d. Grabber Construction Products, Inc.
 - e. Hilti, Inc.
 - f. OSI Sealants; Henkel Corporation.
 - g. Pecora Corporation.
 - h. Specified Technologies Inc.
 2. Colors of Exposed Acoustical Joint Sealants: As selected by Architect from manufacturer's full range of colors.

2.2 MISCELLANEOUS MATERIALS

- A. Primer: Material recommended by acoustical joint-sealant manufacturer where required for adhesion of sealant to joint substrates.
- B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.
- C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints indicated to receive acoustical joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Clean out joints immediately before installing acoustical joint sealants to comply with joint-sealant manufacturer's written instructions.
- B. Joint Priming: Prime joint substrates where recommended by acoustical joint-sealant manufacturer. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.3 INSTALLATION OF ACOUSTICAL JOINT SEALANTS

- A. Comply with acoustical joint-sealant manufacturer's written installation instructions unless more stringent requirements apply.
- B. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical joint sealant. Install acoustical joint sealants at both faces of partitions, at perimeters, and through penetrations. Comply with ASTM C919, ASTM C1193, and manufacturer's written instructions for closing off sound-flanking paths around or through assemblies, including sealing partitions to underside of floor slabs above acoustical ceilings.
- C. Acoustical Ceiling Areas: Apply acoustical joint sealant at perimeter edge moldings of acoustical ceiling areas in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.

3.4 CLEANING

- A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of acoustical joint sealants and of products in which joints occur.

3.5 PROTECTION

- A. Protect acoustical joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated acoustical joint sealants immediately so installations with repaired areas are indistinguishable from original work.

END OF SECTION

SECTION 07 9513.16 - EXTERIOR EXPANSION JOINT COVER ASSEMBLIES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Exterior expansion joint covers.
- B. Related Requirements:
 - 1. Section 07 7129 "Manufactured Roof Expansion Joints" for factory-fabricated roof expansion joint cover assemblies.
 - 2. Section 07 9100 "Preformed Joint Seals" for preformed foam and extruded-silicone joint seals.
 - 3. Section 07 9513.19 "Parking Deck Expansion Joint Cover Assemblies" for expansion joint cover assemblies subject to vehicular traffic.

1.2 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal and Samples submittal. Ensure compliance with requirements included in Section 01 3300 "Submittal Procedures."Section 07 0413 "Common Submittal Requirements for Thermal and Moisture Protection".
- B. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for expansion joint cover assemblies.
 - 1. Exterior expansion joint covers.
- C. Shop Drawings: For each expansion joint cover assembly.
 - 1. Include plans, elevations, sections, details, splices, block-out requirement, attachments to other work, and line diagrams showing entire route of each expansion joint.
 - 2. Where expansion joint cover assemblies change planes, provide isometric or clearly detailed drawing depicting how components interconnect.
- D. Samples: For each exposed expansion joint cover assembly and for each color and texture specified, full width by 6 inches (150 mm) long in size.
- E. Samples for Initial Selection: For each type of exposed finish.
 - 1. Include manufacturer's color charts showing the full range of colors and finishes available for each exposed metal and elastomeric seal material.
- F. Samples for Verification: For each type of expansion joint cover assembly, full width by 6 inches (150 mm) long in size.
- G. Expansion Joint Cover Assembly Schedule: Prepared by or under the supervision of the supplier. Include the following information in tabular form:
 - 1. Manufacturer and model number for each expansion joint cover assembly.
 - 2. Expansion joint cover assembly location cross-referenced to Drawings.
 - 3. Nominal, minimum, and maximum joint width.
 - 4. Movement direction.

5. Materials, colors, and finishes.
6. Product options.
7. Fire-resistance ratings.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: For each fire-resistance-rated expansion joint cover assembly, for tests performed by **[manufacturer and witnessed by a qualified testing agency]** **[a qualified testing agency]**.

1.4 MOCKUPS

- A. Build mockups to demonstrate aesthetic effects and to set quality standards for materials and execution.
 1. Build mockup of typical expansion joint cover assembly as shown on Drawings.
 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Furnish units in longest practicable lengths to minimize field splicing.
- B. Include factory-fabricated closure materials and transition pieces, T-joints, corners, curbs, cross-connections, and other accessories as required to provide continuous expansion joint cover assemblies.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Expansion joint cover assemblies shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. Fire-Resistance Ratings: Provide expansion joint cover assemblies with fire barriers identical to those of systems tested for fire resistance according to **[UL 2079]** **[or]** **[ASTM E1966]** by a qualified testing agency.
 1. Hose Stream Test: Wall-to-wall and wall-to-soffit assemblies shall be subjected to hose stream testing.
- C. Expansion Joint Design Criteria **<Insert drawing designation>**:
 1. Type of Movement: **[Thermal]** **[Wind sway]**.
 - a. Nominal Joint Width: **[As indicated on Drawings]** **<Insert width>**.
 - b. Minimum Joint Width: **[As indicated on Drawings]** **<Insert width>**.
 - c. Maximum Joint Width: **[As indicated on Drawings]** **<Insert width>**.
 2. Seismic Movement:
 - a. Joint Movement: As indicated on Drawings.

2.3 EXTERIOR EXPANSION JOINT COVERS

- A. Exterior Metal-Plate Joint Cover <Insert drawing designation>: Assembly consisting of sliding metal cover plate in continuous contact with gaskets mounted on metal frames fixed to sides of joint gap.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Architectural Art Manufacturing; a division of Pittcon Architectural Metals, LLC.
 - b. Balco; a CSW Industrials Company.
 - c. Construction Specialties, Inc.
 - d. MM Systems Corporation.
 - e. Nystrom, Inc.
 - f. Watson Bowman Acme Corp.
 - g. inpro Corporation.
 2. Application: Wall to wall Wall to soffit Soffit to soffit.
 3. Installation: Surface mounted.
 4. Fire-Resistance Rating: Not less than that indicated on Drawings that of adjacent construction 1 hour 2 hours Insert rating.
 5. Exposed Metal:
 - a. Aluminum: Mill Clear anodic, Class I Clear anodic, Class II Color anodic, Class I Color anodic, Class II Manufacturer's standard Insert finish.
 - 1) Color: Light bronze Dark bronze Match Architect's sample As selected by Architect from full range of industry colors and color densities Insert color.
 - b. Stainless Steel: No. 2B No. 4 Manufacturer's standard Insert finish.
 - c. Bronze: Mill Manufacturer's standard Insert finish.
 - d. Brass: Mill Manufacturer's standard Insert finish.
- B. Exterior Elastomeric-Seal Joint Cover <Insert drawing designation>: Assembly consisting of elastomeric seal anchored to surface-mounted frames fixed to sides of joint gap.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Architectural Art Manufacturing; a division of Pittcon Architectural Metals, LLC.
 - b. Balco; a CSW Industrials Company.
 - c. Construction Specialties, Inc.
 - d. MM Systems Corporation.
 - e. Nystrom, Inc.
 - f. Watson Bowman Acme Corp.
 - g. inpro Corporation.
 2. Application: Wall to wall Wall to soffit Soffit to soffit.
 3. Installation: Surface-mounted Recessed.
 4. Fire-Resistance Rating: Not less than that indicated on Drawings that of adjacent construction 1 hour 2 hours Insert rating.
 5. Exposed Metal:
 - a. Aluminum: Mill Clear anodic, Class I Clear anodic, Class II Color anodic, Class I Color anodic, Class II Manufacturer's standard Insert finish.

- 1) Color: Light bronze Dark bronze Match Architect's sample As selected by Architect from full range of industry colors and color densities Insert color.
 - b. Stainless Steel: No. 2B No. 4 Manufacturer's standard Insert finish.
 - c. Bronze: Mill Manufacturer's standard Insert finish.
 - d. Brass: Mill Manufacturer's standard Insert finish.
 6. Seal: Preformed elastomeric membrane or extrusion.
 - a. Color: Black Gray As selected by Architect from manufacturer's full range Insert color.
 - C. Preformed Foam Joint Seals: Manufacturer's standard joint seal manufactured from urethane or EVA (ethylene vinyl acetate) foam with minimum density of 10 lb/cu. ft. (160 kg/cu. m) and impregnated with a nondrying, water-repellent agent. Factory produce in precompressed sizes in roll or stick form to fit joint widths based on design criteria indicated, with factory- or field-applied adhesive for bonding to substrates.
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Balco; a CSW Industrials Company.
 - b. EMSEAL Joint Systems, Ltd.
 - c. LymTal International, Inc.
 - d. MM Systems Corporation.
 - e. Nystrom, Inc.
 - f. Pecora Corporation.
 - g. Schul International Company, LLC.
 - h. Watson Bowman Acme Corp.
 - i. Willseal LLC.
 2. Design Criteria:
 - a. Nominal Joint Width: **[As indicated on Drawings] <Insert dimension>.**
 - b. Minimum Joint Width: **[As indicated on Drawings] <Insert dimension>.**
 - c. Maximum Joint Width: **[As indicated on Drawings] <Insert dimension>.**
 3. Joint Seal Color: As indicated by manufacturer's designations Match Architect's sample As selected by Architect from full range of industry colors Insert color.
- 2.4 MATERIALS
- A. Aluminum: ASTM B221 (ASTM B221M), Alloy 6063-T5 for extrusions; ASTM B209 (ASTM B209M), Alloy 6061-T6 for sheet and plate.
 1. Apply manufacturer's standard protective coating on aluminum surfaces to be placed in contact with cementitious materials.
 - B. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304 for plates, sheet, and strips.
 - C. Brass: ASTM B36/B36M, UNS Alloy C26000 for half hard sheet and coil.
 - D. Bronze: ASTM B455, Alloy C38500 for extrusions; Alloy C23000 red brass for plates.
 - E. Elastomeric Seals: Manufacturer's standard preformed elastomeric membranes or extrusions to be installed in metal frames.

F. Fire Barriers: Any material or material combination, when fire tested after cycling, designated to resist the passage of flame and hot gases through a movement joint and to comply with performance criteria for required fire-resistance rating.

G. Moisture Barrier: Manufacturer's standard, flexible elastomeric material.

2.5 ALUMINUM FINISHES

A. Mill finish.

B. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm AA-M12C22A31, Class II, 0.010 mm or thicker.

C. Color Anodic Finish: AAMA 611, AA-M12C22A42/A44, Class I, 0.018 mm AA-M12C22A32/A34, Class II, 0.010 mm or thicker.

2.6 STAINLESS STEEL FINISHES

A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.

B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.

1. Run grain of directional finishes with long dimension of each piece.
2. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
3. Directional Satin Finish: No. 4.

C. Bright, Cold-Rolled, Unpolished Finish: No. 2B.

2.7 COPPER-ALLOY FINISHES

A. Buffed Finish: M21 (Mechanical Finish: buffed, smooth specular).

B. Medium-Satin Finish: M32 (Mechanical Finish: directionally textured, medium satin).

2.8 ACCESSORIES

A. Moisture Barriers: Manufacturer's standard continuous, waterproof membrane within joint and attached to substrate on sides of joint.

1. Provide where indicated on Drawings.

B. Manufacturer's standard stainless steel attachment devices. Include anchors, clips, fasteners, set screws, spacers, and other accessories compatible with material in contact, as indicated or required for complete installations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces where expansion joint cover assemblies will be installed for installation tolerances and other conditions affecting performance of the Work.

- B. Notify Architect where discrepancies occur that will affect proper expansion joint cover assembly installation and performance.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prepare substrates according to expansion joint cover assembly manufacturer's written instructions.
- B. Coordinate and furnish anchorages, setting drawings, and instructions for installing expansion joint cover assemblies. Provide fasteners of metal, type, and size to suit type of construction indicated and to provide for secure attachment of expansion joint cover assemblies.

3.3 INSTALLATION

- A. Comply with manufacturer's written instructions for storing, handling, and installing expansion joint cover assemblies and materials unless more stringent requirements are indicated.
- B. Metal Frames: Perform cutting, drilling, and fitting required to install expansion joint cover assemblies.
 - 1. Install in true alignment and proper relationship to joints and adjoining finished surfaces measured from established lines and levels.
 - 2. Adjust for differences between actual structural gap and nominal design gap due to ambient temperature at time of installation.
 - 3. Cut and fit ends to accommodate thermal expansion and contraction of metal without buckling of frames.
 - 4. Install frames in continuous contact with adjacent surfaces.
 - a. Shimming is not permitted.
 - 5. Locate anchors at interval recommended by manufacturer, but not less than 3 inches (75 mm) from each end and not more than 24 inches (600 mm) o.c.
- C. Elastomeric Seals: Install elastomeric seals and membranes in frames to comply with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Provide in continuous lengths for straight sections.
 - 2. Seal transitions. Vulcanize or heat-weld field-spliced joints as recommended by manufacturer.
 - 3. Mechanically lock seals into frames or adhere to frames with adhesive or pressure-sensitive tape as recommended by manufacturer.
- D. Preformed Foam Joint Seals: Install in compliance with manufacturer's written instructions. Install with minimum number of end joints.
 - 1. Install each length of seal immediately after removing protective wrapping.
 - 2. Firmly secure compressed joint seals to joint gap side to obtain full bond using exposed pressure-sensitive adhesive or field-applied adhesive as recommended by manufacturer.
 - 3. Do not pull or stretch material. Produce seal continuity at splices, ends, turns, and intersections of joints.
 - 4. For applications at low ambient temperatures, heat foam joint seal material in compliance with manufacturer's written instructions.

- E. Install with hairline mitered corners where expansion joint cover assemblies change direction or abut other materials.
- F. Terminate exposed ends of expansion joint cover assemblies with field- or factory-fabricated termination devices.
- G. Fire-Resistance-Rated Assemblies: Coordinate installation of expansion joint cover assembly materials and associated work so complete assemblies comply with performance requirements.
 - 1. Fire Barriers: Install fire barriers to provide continuous, uninterrupted fire resistance throughout length of joint, including transitions and field splices.
- H. Moisture Barrier Drainage: If indicated, provide drainage fitting and connect to drains.

3.4 CONNECTIONS

- A. Transition to Roof Expansion Joint Covers: Coordinate installation of exterior wall and soffit expansion joint covers with roof expansion joint covers specified in Section 07 7129 "Manufactured Roof Expansion Joints." **[Install factory-fabricated units at transition between exterior walls and soffits and roof expansion joint cover assemblies.]**

3.5 PROTECTION

- A. Do not remove protective covering until finish work in adjacent areas is complete. When protective covering is removed, clean exposed metal surfaces to comply with manufacturer's written instructions.
- B. Protect the installation from damage by work of other Sections.

END OF SECTION

SECTION 08 1613 - FIBERGLASS (FRP) DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Doors and frames of FRP composite construction. Door and frame products of aluminum, steel or wood construction that use FRP face sheets are not acceptable.
- B. Related Requirements:
 - 1. Section 08 7100 "Door Hardware."

1.2 COORDINATION

- A. Coordinate anchorage installation for FRP frames. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors. Deliver such items to Project site in time for installation.

1.3 ACTION SUBMITTALS

- A. Product Data: Provide catalog cut of FRP door detailing internal construction and reinforcements, materials used and description of assembly process.
- B. Shop Drawings: To include the following specific information:
 - 1. Specifications relating to FRP door thickness, resin type, core material, method of construction, finish color, type of glass and glazing, anchor systems, joint construction and complete warranty information.
 - 2. Complete schedules or drawings of FRP doors and frames (and associated Builders Hardware) showing identifying mark numbers, door and frame types, typical elevations, nominal sizes, handing, actual dimensions and clearances, and required hardware preps and reinforcements.
 - 3. Supporting reference drawings pertaining to frame mounting details, door light or louver installation, hardware locations, and factory hardware cutouts and reinforcements.
- C. Color Samples: Provide a complete set of available finish colors from the manufacturer for color selection upon request.

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer shall have been engaged in the manufacture of FRP door and frame systems for a minimum of five years documented experience prior to the start of this work, and who has a history of successful production of work of this section.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver FRP doors and frames to site in boxes with foam sheet separations. Factory mark all doors and frames using a chemical resistant plastic tag or indelible marker with identifying number, keyed to shop drawings, prior to shipment.

- B. Store doors indoors in a vertical position, clear of the floor, with blocking between the doors to permit air circulation between the doors and prevent damage to the door faces. Rain/water or condensation must not be allowed to collect or lay between stored doors. Do not wrap in plastic sheeting as it will promote condensation formation within. Permanent discoloration can result. Failure to comply with the receiving and reporting instructions shall void the warranty.
- C. Use care in handling FRP doors and frames to prevent damage to factory finishes. Wear protective gloves and do not slide or drag doors or frames against one another.

1.6 WARRANTY

- A. Special Warranty: Manufacturer shall provide limited written warranty for FRP doors and frames as follows:
 - 1. Failure Due To Corrosion: Life of installation.
 - 2. Defective Workmanship: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Overly/Tiger Door.
 - 2. Special-Lite; FRP Flush Door (Basis-of-Design).
 - 3. CECO Door Products.

2.2 PERFORMANCE REQUIREMENTS

- A. Pultruded structural shapes for stiles, rails, frames, and astragals shall exhibit the following minimum longitudinal coupon properties:
 - 1. Tensile Strength: 30,000 psi tested in accordance with ASTM D638.
 - 2. Comprehensive Strength: 30,000 psi tested in accordance with ASTM D695.
 - 3. Flexural Strength: 30,000 psi tested in accordance with ASTM D790.
 - 4. Flexural Modulus: 1,600,000 psi tested in accordance with ASTM D790.
 - 5. Shear Strength: 4,500 psi tested in accordance with ASTM D2846.
 - 6. Impact, Notched: 25 ft-lb/in tested in accordance with ASTM D256.
 - 7. Barcol Hardness: 50 tested in accordance with D2853.
- B. Core material shall exhibit the following minimum coupon properties (per ASTM):
 - 1. Core material must comply with the International Building Code (IBC) chapter 26 requirements for use with a plastic skin.
 - 2. Shear strength, longitudinal direction: 68.2 psi tested in accordance with ASTM C273.
 - 3. Shear strength, transverse direction: 25.8 psi tested in accordance with ASTM C273.
 - 4. Shear modulus, longitudinal direction: 6940 psi tested in accordance with ASTM C273.
 - 5. Shear modulus, transverse direction: 1878 psi tested in accordance with ASTM C273.
 - 6. Shear elongation, longitudinal direction: 1.79 percent tested in accordance with ASTM C393 short beam.
 - 7. Shear elongation, transverse direction: 2.72 percent tested in accordance with ASTM C393 short beam.

8. Maximum facing stress, longitudinal direction: 735 psi tested in accordance with ASTM C393 short beam.
 9. Maximum facing stress, transverse direction: 289 psi tested in accordance with ASTM C393 short beam.
 10. Maximum core shear stress, longitudinal direction: 63.8 psi tested in accordance with ASTM C393 short beam.
 11. Maximum core shear stress, transverse direction: 24.9 psi tested in accordance with ASTM C393 short beam.
 12. Modulus of elasticity (EI) per 1 inch width, longitudinal direction: 4.92E+04 psi tested in accordance with ASTM C393 short beam.
 13. Modulus of elasticity (EI) per 1 inch width, transverse direction: 1.97E+04 psi tested in accordance with ASTM C393 short beam.
 14. Maximum facing stress, longitudinal direction: 9,011 psi tested in accordance with ASTM C393 long beam.
 15. Maximum facing stress, transverse direction: 4,727 psi tested in accordance with ASTM C393 long beam.
 16. Maximum core shear stress, longitudinal direction: (C393 long beam) 48.3 psi tested in accordance with ASTM C393 long beam.
 17. Maximum core shear stress, transverse direction: 23.5 psi tested in accordance with ASTM C393 long beam.
 18. Modulus of elasticity (EI) per 1 inch width, longitudinal direction: 1.14E+05 psi tested in accordance with ASTM C393 long beam.
 19. Modulus of elasticity (EI) per 1 inch width, transverse direction: 7.23E+05 psi tested in accordance with ASTM C393 long beam.
 20. Stiffness "D", longitudinal direction: 379,270 psi tested in accordance with ASTM C393 long beam.
 21. Stiffness "D", longitudinal direction: 260,608 psi tested in accordance with ASTM C393 long beam.
 22. Compressive strength: 53 psi tested in accordance with ASTM C365.
 23. Compressive modulus: 2,110 psi tested in accordance with ASTM C365
 24. Density: 2.42 lb/ft³ tested in accordance with ASTM C271.
- C. Adhesive for bonding pultrusions shall exhibit the following minimum coupon properties:
1. Tensile Strength: Minimum 2,000 psi tested in accordance with ASTM D882-83A modified.
 2. 8 day 25° C at 100% humidity Cross Peel: Minimum 330 psi tested in accordance with SAE J1553.
 3. 7 day immersion in seawater Cross Peel: Minimum 330 psi tested in accordance with SAE J1553.
 4. 30 day immersion in saltwater Cross Peel: Minimum 330 psi tested in accordance with SAE J1553.
 5. 72 hour immersion in gasoline Cross Peel: Minimum 330 psi tested in accordance with SAE J1553.
 6. 72 hour immersion in 20 percent sulfuric acid Cross Peel: Minimum 300 psi tested in accordance with SAE J1553.

2.3 FRP DOORS

- A. Commercial Duty Non-fire rated FRP Doors:

1. Design: FRP doors shall be of seamless construction. Laminated FRP face sheets shall be bonded to an internal door stile and rail channel subframe/core assembly. The composite door panel must be bonded over its entire surface area, not just adhesive-bonded at perimeter stiles and rails.
2. Stiles & Rails: A 1-3/4 inches wide x 1-1/2 inches deep x 5/8 inch web pultruded FRP channel subframe is to be provided within the door. All connections shall be chemically welded. No mechanical fasteners will be allowed. The use or inclusion of aluminum, steel, gypsum or wood into stile and rail construction is not permitted.
3. Core: For maximum rigidity and compressive strength a triangular shaped 3/8 inch cell phenolic resin impregnated kraft paper honeycomb. Molding pressure and adhesive gel time shall be sufficient to allow for penetration of resin into the cellular structure of the core to maximize shear and peel strengths at the skin/core interface. The honeycomb is to be completely enclosed within the stile and rail subframe. Use of foam or balsa wood is not permitted.
4. Internal Reinforcement: High-density polymer compression blocks, or plastic compression blocking at all hardware locations. No wood blocking, steel or aluminum reinforcing plates, ribs or fittings shall be used. A minimum of 900 lbs of pullout strength is required for each factory supplied hinge screw.
5. Faces: Door facings shall utilize a chemical resistant modified polyester copolymer resin system with fiber reinforcing layers. Supplier shall furnish door faces as shown on the drawings and in the door elevations. Structural reinforcement of the face skin shall be in the form of random chopped fiberglass roving.
6. Finish: The exposed FRP door faces shall have a 3-4 mils (wet) factory applied two-part aliphatic polyurethane fully cured coating of industrial urethane. Coating shall have a minimum hardness of H to 2H.
 - a. Texture: As selected by Architect.
 - b. Color: As selected by Architect.
7. Astragals: All pairs of doors shall be furnished with an astragal from door manufacturer made of same pultruded FRP material as door stile, rail and edge as required. Astragal shall be located on the meeting stile edge of each inactive leaf of double door pairs. Architect shall advise active leaf of door, and astragal shall be installed to cover meeting stile gap to effect seal and security.
8. Lights: Glass per job specification shall be factory furnished, glazed and installed. Centered glazing shall be installed between 45 degree pultruded FRP glazing stops and vinyl foam tape with concealed compression retainers for ' glazing. No exposed fasteners or exposed silicone will be allowed for securing ' glazing. Stainless steel screws may be allowed for other glazing thicknesses. Offset glazing shall be installed against a molded-in 5/8" inch wide exterior face flange with a bed of tape caulk, square 5/8" inch pultruded glazing stops with stainless steel screws shall complete the installation to secure the glazing in place and cover all unsightly caulking. Double flush glazing shall be installed with vinyl foam tape and silicone sealant at all edges to complete flush appearance. All glazing stop material shall be pultruded FRP with a minimum fiberglass content of 50 percent. Metal, pvc, or vinyl glass kit type lights are not acceptable for non-fire rated openings.

9. Louvers: Fiberglass inverted V blade privacy or flat blade louvers shall be factory furnished and installed. All louvers and louver trim shall be manufactured exclusively from pultruded FRP profiles with a minimum fiberglass content of 50 percent. All louvers shall be coated to match door in color and sheen. Inverted V blade minimum thickness shall be 3/32 inch thick, flat blade louver minimum thickness shall be 3/16 inch thick. Adhesives for louver assembly shall meet or exceed all requirements set forth in Mechanical Properties and Test Performance article below. Metal, pvc, vinyl or other non-fiberglass louvers are not acceptable for non-fire rated openings.
10. Provisions for lights and louvers shall be performed during manufacture and shall not be attempted in the field. Cutouts are to be totally enclosed by pultruded FRP stiles and rails incorporated into the door structure. Light and louver cutouts that expose core material are not acceptable.

2.4 FRP FRAMES

A. FRP Frames:

1. Design: FRP Door frames furnished under this specification shall utilize a high-modulus pultruded structural FRP shape. The frame section shall be standard double rabbeted 5-3/4 inches deep x 2 inches face, 3/16 inch thick, with integral 5/8 inch doorstop with 1-15/16 inch soffits, or as required to match typical hollow metal configurations.
2. Corner Joints: Frame jambs and header shall be joined at corners via miter connections with hidden FRP angle clips and associated fasteners. Post and beam corners will not be acceptable. Exposed fasteners for miter connections will not be acceptable except for wrap wall applications.
3. Hardware Reinforcements: FRP reinforcing shall be chemically welded to door frame material at required locations. Minimum screw pullout strength of 1100 lb per #12 x 1" sheet metal screw is required. Mechanically fastened reinforcements are not permitted.
4. Anchors:
 - a. Bolt-In Type: Provide manufacturer's required number of 3/8 inch diameter x 4 inches long flat head stainless steel sleeve anchors for masonry openings, 3/8 inch diameter x 4 inches machine screw with nut and washers for structural steel openings, #14 x 4" stainless steel flat head sheet metal screws for wood or steel stud openings. Include extra anchors for additional frame height in two foot increments above 8'-0". Provide single bolt anchor at center of all headers over four feet in nominal width. Stainless Steel fasteners shall be furnished by the factory.
 - b. Grout-In Type: Provide manufacturer's required number of wire or strap type masonry anchors for installation into block wall. Fill frame cavity with grout.
5. Finish: Frames shall have a 3-4 mils (wet) factory applied two-part aliphatic polyurethane fully cured coating of industrial urethane. Industrial urethane chemical coating color topcoat, to match the color and sheen of the doors, for superior weatherability. Gelcoat may not be sprayed onto the frame as a secondary coating.
 - a. Texture: As selected by Architect.
 - b. Color: As selected by Architect.

2.5 FASTENERS

- A. All fasteners for all hardware shall be type 304 CRSS (18-8 series corrosion resistant stainless steel). No carbon steel or aluminum components shall be used.

2.6 HARDWARE

- A. Doors shall be factory mortised and drilled for mortise template butt hinges, with #12x2 inches long stainless steel screws provided for hinge attachment. Provide 161 cylindrical lock bore, rim deadbolt, ANSI 86 mortise lock edge prep and pocket, or flushbolt cutouts as required.
- B. Frames shall be factory machined and drilled for all hardware requiring mortises, with #12x1 inch long stainless steel screws pre-installed for hinge attachment.
- C. Hardware: Specified in Section 08 7100 "Door Hardware."
- D. Provide manufacturer's standard templates, installation instructions, or full size approved door and frame preparation instructions as approved by the architect and as required by door and frame manufacturer prior to door and frame factory initiated manufacture. Standard factory lead-time for production of FRP doors and frames shall commence only and when all distributor required preparation information is received and acknowledged by the door and frame manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual dimensions of openings by field measurements before door fabrication; show recorded measurements on shop drawings.
- B. Do not begin installation until substrates have been properly prepared.

3.2 PREPARATION

- A. Clean and prepare substrates in accordance with manufacturer's instructions.

3.3 INSTALLATION

- A. Install frames in accordance with manufacturer's written instructions. Set plumb and square, using shims for bolt-in of existing openings, or wood bracing prior to grouting of jambs. Use at least two 2x6 wood spreaders inside frame to maintain critical opening dimensions during grouting.
- B. Hang doors in accordance with manufacturer's written instructions using special screws provided for hinge attachment. Install doors to swing freely and to stand open at any angle. After installation make final adjustments to hardware to allow for proper door operation and latching. All surface applied hardware shall be through bolted.
- C. Set units plumb, level, and true-to-line, without warping or racking doors.
- D. Repair or replace damaged products.

3.4 ADJUSTING

- A. Lubricate, test, and adjust doors to operate easily, free from warp, twist or distortion, and to fit watertight for entire perimeter.
- B. Adjust hardware for smooth and quiet operation.
- C. Adjust doors to fit snugly and close without sticking or binding.

3.5 CLEANING

- A. Clean exposed surfaces of FRP doors and frames with a mild, non-abrasive cleaner and water as recommended by door manufacturer.

3.6 PROTECTION

- A. Protect installed products from subsequent construction operations.

END OF SECTION

FOR REFERENCE ONLY

SECTION 08 3453 - ANIMAL ENCLOSURE CAGING & DOORS**PART ONE - GENERAL****1.1 REFERENCE STANDARDS**

- A. AAMA 2603 - Voluntary Specification, Performance Requirements and Test Procedures for Pigmented Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix); 2026.
- B. AAMA 2604 - Voluntary Specification, Performance Requirements and Test Procedures for High Performance Organic Coatings on Aluminum Extrusions and Panels (with Coil Coating Appendix); 2026.
- C. ASTM A307 - Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength; 2021.
- D. ASTM A500/A500M - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes; 2023.
- E. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes; 2021.
- F. ASTM B632/B632M - Standard Specification for Aluminum-Alloy Rolled Tread Plate; 2024.
- G. ASTM D3451 - Standard Guide for Testing Coating Powders and Powder Coatings; 2024.
- H. SSPC-SP 1 - Solvent Cleaning; 2015, with Editorial Revision (2016).

1.2 SUMMARY

- A. Section Includes:
 - 1. Provide all animal caging and keeper access doors.
 - 2. Caging systems consist of metal door and caging frames, solid, mesh, and HDPE panels, and door hardware.
 - 3. Fabricate and install caging and door systems, as shown on the drawings, specified herein, or needed for a complete and proper installation.
 - 4. Folding FRP/HDPE platform with Metal supports
- B. Related Sections:
 - 1. Section 03 30 00 Cast-in-Place Concrete
 - 2. Section 04 20 00 Unit Masonry
 - 3. Section 06 10 00 Rough Carpentry
 - 4. Section 08 80 00 Glazing
 - 5. Section 09 91 00 Painting

1.3 SYSTEM DESCRIPTION:

- A. Delegated Design:
 - 1. The work of this section requires professional design services or certifications by a design professional employed by the fabricator, and who is not the Consultant.
 - 2. Complete the design of the doors, frames, panels, and connections.
 - 3. Maintain the general design concept shown.
 - 4. Do not change member sizes or alter profiles and alignment, except as outlined in the design processes of this section.
- B. Performance Standards:
 - 1. The work this section must fulfill the minimum material requirements described in Part 2 of this section.

2. The fabricator is free to propose an alternate framing system to support the mesh, doors, and animal doors specified in section 08 34 56 Animal Access Doors.
 3. Materials specified herein are intended to establish the standards of quality required for the Work of this Section.
 4. Provide appropriate documentation that all proposed materials meet the specific performance and structural requirements specified below.
 5. All materials and/or completed fabrications must have a twenty (20) year structural service life.
 6. All materials must be capable of resisting the loads and all potential wear and abrasions inherent in their position within the completed exhibits.
 7. The Owner will make final approval of the proposed system.
- C. Structural Systems Design:
1. Structural Design:
 - a) Provide the structural engineering design for the doors, frames, hardware, fixed panels, and all connections.
 - b) Drawings and Calculations:
Provide complete design, calculations, and drawings, prepared and signed in accordance with pertinent provisions of division one of these Specifications.
 - c) Licensed Engineer:
Design drawings will be prepared, approved, signed and sealed by a professional engineer licensed in the jurisdiction in which the project will be constructed.
 2. General Design Loads:
Design all elements for the following loads:
 - a) Dead loads,
 - b) Live loads due to animals and keeper staff,
 - c) Wind loads as required by local code.
 3. Animal Design Criteria:
 - a) All Animals:
 - 1) Horizontal Force is 500 lbs.
 - 2) Impact occurs 4-ft above bottom of panel.
 - 3) Impact occurs over 1-ft².
- D. Approvals and Permits:
1. General:
Secure the approval of governmental agencies having jurisdiction prior to submitting for the Consultant's approval.
 2. Building Permits:
Obtain all required permits and approvals for proposed systems.

1.4 SUBMITTALS

- A. General:
1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
 2. Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit all items listed below.
- B. Design Drawings:
1. Delegated Design:

- a) Submit complete drawings accurately showing proposed all the fabrications and equipment described in this section, prepared in accordance with the following provisions:
- b) Verify materials selection and sizes.
- c) Verify fabrication and connection details for the fabrications or suggest alternative connection details.
- d) Design system utilizing the system components specified in Part 2 of this specification.
- e) Revise drawings as required by the Owner and resubmit.
- 2. Delegated Design Submittals:
 - a) Provide all submittals described in Section 01 33 50 as required for the work of this section.
- 3. Design Notes and Calculations:
 - a) When requested by Consultant, submit design notes and calculations, signed and sealed by the Professional Engineer.
- C. Product Data:
 - 1. A complete list of materials proposed to be furnished and installed under this Section.
 - 2. Manufacturer's specifications and other data needed to demonstrate compliance with specified requirements.
 - 3. Manufacturer's recommended installation procedures which, when approved by the Owner, will become the basis for accepting or rejecting actual installation procedures used on the work.
 - 4. All stainless steel items require manufacturer's certification of type of stainless steel used.
- D. Shop Drawings:
 - 1. Submit fully detailed layout, fabrication, and erection drawings of all materials specified herein for approval.
 - 2. Drawings shall show all members, shop cuts, and holes, erection sequences, and tolerances.
 - 3. Provide templates for anchor and bolt installation by other trades.
 - 4. No fabrication or Work shall be commenced until Shop Drawings have been reviewed and returned to the Contractor.
 - 5. Fabricate from reviewed drawings only.
 - 6. Provide engineered drawings stamped by a structural engineer licensed in the jurisdiction in which the project is located.
- E. Samples:
 - 1. Provide a 2-ft length or square piece of each type, size, finish, and grade of each specified material.
 - 2. Provide a sample of each piece of hardware specified.

1.5 QUALITY ASSURANCE

- A. Standards:
 - 1. Building Codes:
 - a) International Building Code, latest edition, as modified by the local jurisdiction.
 - b) Relevant Building Code for the jurisdiction in which the project is being constructed.
 - 2. Materials and Fabrication Standards:
 - a) 'Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings' by AISC, latest edition.
 - b) AISC "Specifications for Design, Fabrication, and Erection of Structural Steel for Buildings", 8th Edition;

- c) AISC "Code of Standard Practice";
- d) AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
- 3. American Society for Testing and Materials (ASTM):
 - a) ASTM A27-10, Standard Specification for Steel Castings, Carbon, for General Application
 - b) ASTM A47-99(2009)/A47M-99(2009), Standard Specification for Ferritic Malleable Iron Castings
 - c) ASTM A53-10, Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
 - d) ASTM A123-09/A123M-09, Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
 - e) ASTM A153-09/A153M-09, Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
 - f) ASTM A500/A500M-10a, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
 - g) ASTM A572-07/A572M-07, Standard Specification for High Strength Low Alloy Columbium Vanadium Structural Steel
 - h) ASTM A780-09/A780M-09, Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
- 4. Welding:
 - a) Perform welding with electric arc process and in accordance with AWS "Code for Arc and Gas Welding in Building Construction."
 - b) Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedures".
 - c) Welder shall be certified in conformance with (AWS) (WABO) requirements.
- B. Qualifications:
 - 1. Established firm or individual with a minimum of five (5) years' experience in successfully constructing elements of similar nature to the work of this section.
 - 2. Provide resumes for key personnel performing the work.
 - 3. Submit references and photographic documentation of previous projects documenting the experience and ability to construct the work of this section.

1.6 PRODUCT HANDLING

- A. General:

Comply with the pertinent provisions of Sections of 01 60 00 Product Requirements.
- B. Protection:

Use all means necessary to protect the materials of this section before, during, and after installation and to protect the Work and materials of all other trades.
- C. Replacements:

In the event of damage, immediately make all repairs and replacements necessary to the approval of the Owner at no additional cost to the Owner.

1.7 PROJECT CONDITIONS

- A. Field Measurements:

Secure all field measurements required for proper and adequate fabrication and installation of the work.
- B. Templates:

Furnish templates for exact location of items to be embedded in concrete and masonry and setting instructions required for all installation work.

PART TWO - PRODUCTS

2.1 ACCEPTABLE CAGING FABRICATORS

A. Acceptable Fabricators:

The following list of fabricators and installers is derived from previous projects indicating a successful record of fabrication and installation of similar complexity and extent as required for this project and are subject to verification of their capabilities before starting work of this section by submittal of documentation indicating that they meet the specified qualifications:

B. Acceptable Caging Contractors:

1. LGL Animal Care Products, Inc
(979) 690-3434
Contact: John Eppes
jeppes@lgacp.com
www.lgacp.com
2. Thermeq
(419) 878-4400
info@thermeq.com
www.thermeq.com
3. Corners Limited
1-800-456-4400
www.cornerslimited.com
4. Duwe Metals
262-781-5775 (Justin Warzala)
jwarzala@duwemetal.com

C. Substitute Fabricators:

1. The Contractor may choose to select any of the listed fabricators or installers in accordance with Section 01 62 00 – Product Options or elect to solicit additional fabricators installers having similar qualifications, experience and proven capabilities as the acceptable installers listed above and provided that the Contractor makes requests for substitution in accordance with Section 01 25 00 – Substitutions a minimum of ten (10) days in advance of Bid Closing as follows:
 - a) Bidders wishing to use a fabricator or installer that is not identified in this Section must have the proposed fabricator comply with qualification requirements listed herein and submit a letter of qualification, including references a minimum of five (5) 8½” x 11” color photographs of previous comparable work for review and acceptance by the Consultant.
 - b) Fabricators wishing to be accepted for the work of this section may independently make application directly to the Consultant as detailed above.
 - c) Acceptance of substitute fabricators will be indicated by a subsequent addendum.
 - d) The Consultant may require additional information and may request a visit to a completed work in order to make a final determination of the fabricator’s qualifications.

2.2 MATERIAL STANDARDS

A. Surface Quality:

For fabrication of the Work of this Section, which will be exposed to view, use only those materials, which are smooth and free from surface blemishes including pitting, seam marks, roller marks, rolled trade names, and roughness.

B. Stainless Steel:

All materials shall comply with:

1. Stainless Steel Tube/Pipe:
 - a) Cold-formed, round, seamless stainless steel tubing complying with ASTM A511. Grade B.
 - b) Schedule 40 or 80 stainless steel pipe, Type 304/304L, ASTM A312
2. Plates and Bars:

Stainless steel conforming to ASTM A480, Type 304/304L.
3. Stainless steel tube:
 - a) ASTM A269, Type 316L.
4. Stainless steel rod:

ASTM A564, Type 316L. Class A finish.
5. Stainless steel plate:

ASTM A480, Type 316L. Number 1 finish.
6. BS EN 10263-1:2001, Stainless steel.
7. BS EN 10263-5:2001, Stainless steel.
8. BS 3111:Pt.2, Stainless steel fasteners.
9. BS EN ISO 3506 Pt1-3 Mechanical properties of corrosion-resistant stainless-steel fasteners.
10. BS 4320 & BS 4464, Stainless steel washers.
11. BS 6323, Stainless steel tubes for structural and general engineering purposes, Pt 1 & Pt 8, Type 316.
12. BS EN 919:1995, Fibre ropes

C. Bronze:

1. Bushings and Thrust Washers.
2. Iron bronze sintered bearings (oil impregnated) ASTM B612-91, Oilite Bronze or equal.

D. Aluminum:

All materials shall comply with:

- a) Aluminum tube:

Type 5052.
- b) Aluminum Sheet:

Type 5052-H32 or 6061-T6, 3.2mm (1/8-inch, 8-gauge) minimum thickness.
- c) Aluminum Extrusions: In accordance with ASTM B221/B221M, alloy 6063-T6
- d) Aluminum Alloy Rolled Tread Plate: In accordance with ASTM B632/B632M, alloy 6061-T6

E. Fasteners:

1. General:
 - a) Provide stainless steel fasteners.
 - b) Select fasteners for the type, grade, and class required.
2. Standards:

All fasteners listed below shall comply with ASTM A307 and as follows:

 - a) Bolts and nuts: Regular hexagon-head type, Grade A.
 - b) High strength bolts: ASTM A325N bearing type and ASTM A325F friction type.
 - c) Stainless steel bolts, screws, studs: ASTM F738M, Type 316.

- d) Stainless steel nuts: ASTM F836M-91, Type 316.
- e) Plain washers: Round, carbon steel, complying with Fed Spec FF-W-92.
- f) Masonry anchorage devices: Expansion shields complying with Fed Spec FF-S-325.
- g) Concrete Inserts:
 - 1) Threaded or wedge type, galvanized ferrous castings, either malleable iron ASTM A47 or cast steel ASTM A27.
 - 2) Provide bolts, washers, and shims as required, hot-dip galvanized, ASTM A153.
 - 3) Fastener to be compatible with bolt and installed condition to prevent electrolytic-reaction induced corrosion

F. Grout:

- 1. General:
 - a) Provide non-Metallic, non-shrink cement grout, meeting all requirements of ASTM C1107.
- 2. Acceptable Manufacturers:
 - a) "SonogROUT" as manufactured by Sonneborn Building Products or approved.
- 3. Provide grout specifically recommended by manufacturer for type of application.
- 4. Pre-mixed, factory-packaged, non-staining, non-corrosive, non-gaseous grout complying with CE CRD-C621.

2.3 ANIMAL CAGING AND DOORS

A. Door and Panel Frames:

- 1. Steel Angle Frame and Sliding Door Channel Options:
 - a) Light Strength
1-3/16 inch equal legs and .2-inch wall thickness
 - b) Moderate Strength
1-5/8 inch equal legs and .2-inch wall thickness
 - c) Heavy Strength
2 inch equal legs and .2-inch wall thickness
- 2. Connections:
 - a) All frames are miter cut and welded with wire feed.
 - b) Provide bolted connections to adjacent frames, panels, or concrete substrates.

B. Door and Panel Bar Infill

- 1. Round Tube:
 - a) 3/4-in. diameter
 - b) Continuously weld at frame and periodically where it passes through flat bar.
- 2. Flat Bar:
 - a) 1/2" x 2"
 - b) Weld to frame continuously at each end.
- 3. All welds shall be deburred, and materials shall be acid washed.

C. Wire Mesh Panels

- 1. 2" Mesh panels,
 - a) Material: type 304 stainless steel woven and crimped wire mesh
 - b) Opening 2 inch by 2 inch

2.4 HARDWARE

A. General:

- 1. See Section 08 71 00 for requirements for general quality, keying and cores, and installation.

- B. Acceptable Manufacturers:
 - 1. AssaAbloy, www.assaabloy.com
 - 2. Richards Wilcox, www.rwhardware.com, Aurora, Illinois, tel: (800) 253-5668.
 - 3. McKinney, www.mckinneyhinge.com.
 - 4. Stanley, www.stanley.com.
 - 5. Yale Padlock (AssaAbloy), www.yalecommercial.com
 - 6. Best Padlock, www.bestaccess.com.
 - 7. Master Lock Padlock, www.masterlock.com.
 - 8. Schaefer Marine, www.hardware.schaefermarine.com/
 - 9. Ajustlock, www.ajustlock.com/
- C. Cane Bolt:
 - 1. Stanley Cane Bolt
 - 2. 300mm length, 13mm bolt diameter.
 - 3. Type 304 Stainless Steel.
 - 4. Provide Cane Bolt receptacle in both open and closed gate positions.
- D. Sliding Padlock Bolt:
 - 1. Ajustlock Slide Bolt Lock
 - 2. Type 304 Stainless Steel
- E. Handle:
 - 1. Aluminum or Stainless-Steel Bow Handle, 6.5 inch (165.1 mm) long
- F. Heavy Weight Bearing Hinge:
 - 1. McKinney 5 Knuckle, Heavy Weight, Ball Bearing Hinges
 - 2. Model T4B 3386
 - 3. Full mortise, heavy weight, stainless steel base material, and pin, ball bearing hinges.
 - 4. Attach with stainless steel fasteners of the appropriate grade
- G. Pintle and Gudgeon Hinge:
 - 1. Shaefer Marine Pintle:
 - a) SCH8046: Upper 1-in with ½-in Pin
 - b) Type 304 Stainless Steel
 - 2. Shaefer Marine Gudgeon:
 - a) SCH8143: ½-in Pin
 - b) Type 304 Stainless Steel
 - 3. Attach with stainless steel fasteners of the appropriate grade
- H. Padlock:
 - 1. Best Padlock 41B Series
 - 2. Case machined from solid brass, 626 satin chromium plated.
 - 3. Width: 1-15/16-inch, Length: 2-1/16-inch.
 - 4. Thickness: 7/8-inch.
 - 5. Stainless steel shackle: 3/8-inch diameter, 7/8-inch opening.
 - 6. Non-key retaining.
 - 7. Keyed per Zoo's keying system
- I. Sliding Door Track, Truck and Hanger Assemblies & Accessories
 - 1. Track, truck and hander assembly, size as required for weight of door.
 - 2. Accessories:
 - a) Floor Stay Guides
 - b) Bumper Shoes

- c) Guide Roller Strip
 - d) End Stops
- 3. All non-corrosive components: Stainless Steel or Aluminum.
- J. Stops:
 - 1. Stainless Steel or Aluminum stops for both open and closed positions.
 - 2. Match finish of gate frames.
 - 3. Provide product information for manufactured stops: provide shop drawings for custom stops.
 - 4. Provide rubber cushion on metal stop.

2.5 REMOTE DOOR OPERATOR SYSTEMS

A. General:

Construct remote operator systems of non-corrosive components as shown on the drawings.

- 1. Maximum operating force is 30 lbs
- 2. Design door operators with materials and material sizes appropriate for the animals being contained.
- 3. Provide all covers or other protection required for the safety of both humans and animals.
- 4. Design system so that each door can be locked in either an open or closed position.
- 5. Provide conduit for cables

B. Crank Operator:

- 1. Sprocket and chain system with a rotating handle, which operates the wire rope cable system, which is attached to the door.
- 2. Verify all required clearances for the system during the systems design and prototyping of the system.
- 3. Overall size of operator (including handle) no greater than 15" deep.
- 4. Verify all required clearances for the system during the systems design and prototyping of the system.

C. Hydraulic Operator:

- 1. Atos Hydraulic cylinders with adjustable proximity sensor and remote operator, or equal

D. Wire Rope Cable:

- 1. Manufacturers:
United States Steel (USS), Tiger Brand wire rope, WireCo, www.wirecoworldgroup.com,
Loos & Co, www.loosco.com, Hackensack or approved equal.
- 2. Materials:
6 by 42 Tiller rope, galvanized improved plow steel, 2.4mm (3/32-inch) diameter or size as shown.

E. Wire Rope Blocks:

- 1. Manufacturers:
 - a) The MRO Group, Block Division Inc, www.blockdivision.com
 - b) J. Henry Holland Corp, www.jhenryholland.com,
 - c) Or approved equal.
- 2. Materials:
 - a) Standard flat blocks, zinc plated steel with plated steel sheaves and oil impregnated bronze bushings, grooved for wire rope.
 - b) 62mm (2-1/2-inch blocks): Model 02558.
 - c) 88mm (3-1/2-inch blocks): Model 03558.
 - d) Use the largest block diameters appropriate for the constraints of the space available.

- F. Nylon Wire Rope Blocks:
1. Nylon Sheave Manufacturers:
 - a) Ronstan, www.ronstan.com
 - b) Essinger, www.essingercastnylon.com
 - c) Timco, www.timco-eng.com
 - d) Approved equal.
 2. Materials:
 - a) General: Nylon sheaves with zinc plated or stainless steel mounting structure.
 - b) Material: cast nylon 6 or extruded nylon 6/6.
 - c) Bearings: ball bearing or oilite bronze bearings with hardened stainless steel shaft.
 - d) Minimum Sheave Size: 3-inch (76mm) diameter at wire rope cable.
 - e) Use the largest block diameters appropriate for the constraints of the space available.
- G. Wire Rope Clamp Plate:
1. Description:
 - a) Stainless steel plate assembly, both plates grooved to secure wire rope.
 - b) Connect the steel plates with metal tabs on one side and two threaded fasteners on the other to secure the wire rope with friction.
 - c) Join the clamp plate to the guillotine doors or other hardware as shown on the drawings and the approved shop drawings.
- H. Steel Guide Rail and Track Roller:
1. Description:
 - a) Stainless guide rail track, secured to the top of the two combination keeper / animal doors,
 - b) Provide a stainless steel track roller appropriate in size for the track.
 - c) The track roller will have a stainless steel pin at the top to provide a connection to the wire rope clamp plate for this assembly.
 - d) Provide a secure connection between the track roller pin and clamp plate to prevent their separation under the load provided above.

2.6 HARDWARE GROUPS:

- A. HWG - 01 – Swing Doors
- 2 pair Hinges
 - 1 ea Cane Bolt
 - 1 ea Sliding Padlock Bolt
 - 1 ea Handle
 - 2 ea Door Stops with Rubber Pad in Open and Closed positions
 - 1 ea Padlock
- B. HWG - 02 – Horizontal Sliding - Remote operation
- 1 ea Track, Trucks, Hanger Assembly & Accessories
 - 1 ea Door pull
 - 1 ea Remote door operator
- C. HWG - 03 – Horizontal Sliding - Remote Hydraulic operation
- 1 ea Track, Trucks, Hanger Assembly & Accessories
 - 1 ea Door Pull
 - 1 ea Remote Hydraulic operator
- D. HWG - 04 – Vertical Sliding - Guillotine - Remote operation
- 1 ea Sheaves, cables, hanger assembly

- 1 ea Remote door operator
- E. HWG - 05 – Vertical Sliding - Guillotine - Remote hydraulic operation
 - 1 ea Sheaves, cables, hanger assembly
 - 1 ea Remote Hydraulic operator

2.7 GENERAL FABRICATION:

A. Quality

1. Conform to the Quality Assurance standards for this work.
2. Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability of connecting material in the finished product.
3. Work to dimensions shown or accepted on the Shop Drawings, using proven details of fabrication and support.
4. Use type of materials shown or specified for the various components of the Work.
5. Form exposed Work true to line and level, with accurate angles and surfaces and with straight sharp edges.
6. Ease the exposed edges to a radius of approximately 0.03 inch (0.8 mm) unless otherwise shown.
7. Weld corners and seams continuously, complying with welding standards recommendations.
8. At exposed connections, grind exposed welds smooth and flush; match and blend with adjoining surfaces.
9. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners wherever possible.
10. Provide for anchorage of the type shown. Coordinate with supporting structure. Fabricate and space the anchoring devices to provide adequate support for intended use.
11. Cut, reinforce, drill, and tap the work as indicated to receive finish hardware and similar items.

B. Loose Bearing and Leveling Plates:

1. Provide loose bearing and leveling plates for steel items bearing on concrete construction, made flat, free from warps or twists, and of required thickness and bearing area.
2. Drill plates to receive anchor bolts and for grouting as required.

C. Fastening:

1. General.
 - a) Provide malleable iron washers for heads and nuts, which bear on wood structural connections; elsewhere furnish steel washers.
 - b) Cut, drill, and tap units to receive hardware.
 - c) Equip units with integrally welded anchors for casting into concrete or building, into masonry, and furnish inserts if units must be installed after concrete is placed.
 - d) Space anchors 600mm (24-in) on centers, except where shown otherwise on the drawings.
2. Hardware:
 - a) Manufactured Hardware:
 - 1) Fasten to substrates and frames using stainless steel screws, and bolts, using the sizes as recommended by the hardware manufacturer.
 - b) Custom Hardware:
 - 1) Fasten to substrates and frames as shown in the reviewed design and shop drawings.

2.8 FINISHES

A. Galvanizing:

1. Galvanize all steel following fabrication in compliance with the following specifications:
2. ASTM A 153 for galvanizing iron and steel hardware.
3. ASTM A 123 for galvanizing rolled, pressed, and forged steel shapes, plates, bars, and strip 0.12 inch (3 mm) thick and heavier.
4. ASTM A 386 for galvanizing assembled steel products.
5. AS/NZS 4680 Hot Dip Galvanized (zinc) Coatings
6. AS/NZS 1627 Preparation and Pre-treatment of Surfaces
7. All galvanized work to be performed true to line and level as required in shop before delivery to the job site.

B. Field Galvanizing Repair

1. Use a high zinc dust content paint for re-galvanizing welds in galvanized steel, complying with MIL-P-21035.
2. Repair in accordance with applicable requirements of ASTM A780
3. Apply and repair in accordance with AS/NZS 4680 Hot Dip Galvanized (zinc) Coatings
4. Products:
"Galvicon" by Galvicon Corp., "Drygalv" by Anchor Brand Co., "Tot-Rust" (with aluminum color added) by Wilbur & Williams Co. or equal. OTHER MATERIALS Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Owner.

2.9 OTHER MATERIALS

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Owner.

PART THREE - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Examine the areas and conditions under which doors, frames, and panels are to be installed, and correct conditions detrimental to the proper and timely completion of the Work.
2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General:

1. Furnish setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, anchor bolts, and miscellaneous items having integral anchors, which are to be embedded in concrete construction. Coordinate delivery of such items to project site.

3.3 INSTALLATION

A. Shop Drawings:

1. Install the work of this section in strict accordance with the Shop Drawings as approved by the consultant.

B. General:

1. Install doors and hardware in accordance with manufacturer's data, and as specified herein.

C. Placing Supports and Frames:

1. Place supports and frames prior to construction of enclosing structure.
2. Set supports and frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set.

D. Door Installation:

1. Fit doors accurately in their respective frames.
2. Clearances between doors and posts or frames shall vary from 9.6mm (3/8-inch) minimum to 19mm (3/4-inch) maximum.

3.4 ADJUST AND CLEAN

A. Final Adjustments:

1. Leave Work in complete and proper operating condition.
2. Remove and replace defective Work, including gates or frames, which are warped, bowed or otherwise damaged.

B. Finishes:

1. Galvanized Finish:
2. Clean abraded areas and apply galvanizing repair paint to comply with ASTM A780
3. Hot Dip Galvanized (zinc) Coatings.
4. Powder Coated Finish:
5. Repair powder coated finishes with products and procedures that achieve the closest possible match with the shop applied powder coat.

END OF SECTION

SECTION 08 4313 - ALUMINUM-FRAMED STOREFRONTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes aluminum-framed storefront systems.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. <Insert requirements>.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- B. Sustainable Design Submittals:
 - 1. Product Data: For sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
 - 3. Environmental Product Declaration (EPD): For each product.
 - 4. Health Product Declaration: For each product.
 - 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Shop Drawings: For aluminum-framed storefronts. Include plans, elevations, sections, full-size details, and attachments to other work.
 - 1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
 - 2. Include full-size isometric details of each type of vertical-to-horizontal intersection of aluminum-framed storefronts, showing the following:
 - a. Joinery, including concealed welds.
 - b. Anchorage.
 - c. Expansion provisions.
 - d. Glazing.
 - e. Flashing and drainage.
 - 3. Show connection to and continuity with adjacent thermal, weather, air, and vapor barriers.
- D. Samples for Initial Selection: For units with factory-applied color finishes.
- E. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.
- F. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch (300-mm) lengths of full-size components and showing details of the following:
 - 1. Joinery, including concealed welds.
 - 2. Anchorage.
 - 3. Expansion provisions.

4. Glazing.
5. Flashing and drainage.

- G. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
 1. Provide delegated-design submittals for aluminum-framed storefronts.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For aluminum-framed storefronts to include in maintenance manuals.
- B. Maintenance Data for Structural Sealant: For structural-sealant-glazed storefront to include in maintenance manuals. Include ASTM C1401 recommendations for post-installation-phase quality-control program.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer and that employs a qualified glazing contractor for this Project who is certified under the North American Contractor Certification Program (NACC) for Architectural Glass & Metal (AGM) contractors and that employs glazing technicians certified under the Architectural Glass and Metal Technician (AGMT) certification program.
- B. Testing Agency Qualifications: Qualified in accordance with ASTM E699 for testing indicated and acceptable to Owner and Architect.
- C. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
 1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.
- D. Structural-Sealant Glazing: Comply with ASTM C1401 for design and installation of storefront systems that include structural glazing.
- E. Provide the following upon request:
 1. Qualification Data:
 - a. For Installer.
 - b. For professional engineer's experience with providing delegated-design engineering services of the type indicated, including documentation that engineer is licensed in the [jurisdiction] [state] in which Project is located.
 2. Energy Performance Certificates: For aluminum-framed storefronts, accessories, and components, from manufacturer.
 - a. Basis for Certification: NFRC-certified energy performance values for each aluminum-framed storefront.
 3. Product Test Reports: For aluminum-framed storefronts, for tests performed by manufacturer and witnessed by a qualified testing agency.

4. Quality-Control Program: Developed specifically for Project, including fabrication and installation, in accordance with recommendations in ASTM C1401. Include periodic quality-control reports.

1.6 MOCKUPS

- A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for fabrication and installation.
 1. Build mockup of typical wall area as shown on Drawings.
 2. Testing shall be performed on mockups in accordance with requirements in "Field Quality Control" Article.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Owner will engage a qualified testing agency to perform preconstruction testing on laboratory mockups.
 1. Build preconstruction laboratory mockups at testing agency facility; use personnel, products, and methods of construction that will be used at Project site.
 2. Size and Configuration: As indicated on Drawings.
 3. Notify Architect seven days in advance of the dates and times when preconstruction laboratory mockups will be constructed and tested.
- B. Preconstruction Laboratory Mockup Testing: Test preconstruction laboratory mockups in accordance with requirements in "Performance Requirements" Article. Perform the following tests in the following order:
 1. Structural, 50 percent: ASTM E330/E330M at 50 percent of positive test load.
 2. Air Leakage: ASTM E283.
 3. Water Penetration under Static Pressure: ASTM E331.
 4. Water Penetration under Dynamic Pressure: AAMA 501.1.
 5. Structural, 100 percent: ASTM E330/E330M at 100 percent of positive and negative test loads. Repeat the following:
 - a. Air Leakage: ASTM E283.
 - b. Water Penetration under Static Pressure: ASTM E331.
 6. Thermal Cycling: In accordance with AAMA 501.5. Repeat the following:
 - a. Air Leakage: ASTM E283.
 - b. Water Penetration under Static Pressure: ASTM E331.
 7. Structural, 100 and 150 percent: ASTM E330/E330M at 100 and 150 percent of positive and negative test loads. Repeat the following:
 - a. Air Leakage: ASTM E283.
 - b. Water Penetration under Static Pressure: ASTM E331.
- C. Preconstruction Adhesion and Compatibility Testing: Submit to structural glazing sealant manufacturer, for testing indicated below, Samples of each glazing material type, tape sealant, gasket, glazing accessory, and glass-framing member that is in close proximity to or is touching the structural or nonstructural sealants of a structural glazed system.
 1. Compatibility: Test materials or components using ASTM C1087.

2. Adhesion: Test for adhesion or lack of adhesion of a structural sealant to the surface of another material or component using ASTM C1135.
3. Submit no fewer than eight pieces of each type of material, including joint substrates, shims, joint-sealant backings, secondary seals, and miscellaneous materials.
4. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
5. For materials failing tests, obtain sealant manufacturer's written instructions for corrective measures, including the use of specially formulated primers.
6. Testing will not be required if data based on previous testing of current sealant products match those submitted.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of aluminum-framed storefronts that do not comply with requirements or that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including, but not limited to, excessive deflection.
 - b. Noise or vibration created by wind and thermal and structural movements.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - d. Water penetration through fixed glazing and framing areas.
 - e. Failure of operating components.
 2. Warranty Period: 10 years from date of Substantial Completion.
- B. Special Finish Warranty, Anodized Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of anodized finishes within specified warranty period.
 1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D 2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D 4214.
 - c. Cracking, peeling, or chipping.
 2. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Arcadia, Inc.
 2. Kawneer North America, an Arconic company.
 3. Oldcastle BuildingEnvelope (OBE); CRH Americas.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design aluminum-framed storefronts.
 1. Material properties indicated in this Section shall be considered as minimum properties.

- B. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed storefronts representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.
1. Aluminum-framed storefronts shall withstand movements of supporting structure, including, but not limited to, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
 2. Failure also includes the following:
 - a. Thermal stresses transferring to building structure.
 - b. Glass breakage.
 - c. Noise or vibration created by wind and thermal and structural movements.
 - d. Loosening or weakening of fasteners, attachments, and other components.
 - e. Failure of operating units.
- C. Structural Loads:
1. Wind Loads: As indicated on Drawings.
 2. Other Design Loads: As indicated on Drawings.
- D. Deflection of Framing Members Supporting Glass: At design wind load, as follows:
1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans of up to 13 feet 6 inches (4.1 m) and to 1/240 of clear span plus 1/4 inch (6.35 mm) for spans greater than 13 feet 6 inches (4.1 m).
 2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch (3.2 mm).
 - a. Operable Units: Provide a minimum 1/16-inch (1.6-mm) clearance between framing members and operable units.
 3. Cantilever Deflection: Limited to 2/175 at unsupported cantilevers.
- E. Structural: Test in accordance with ASTM E330/E330M as follows:
1. When tested at positive and negative wind-load design pressures, storefront assemblies do not evidence deflection exceeding specified limits.
 2. When tested at 150 percent of positive and negative wind-load design pressures, storefront assemblies, including anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
 3. Test Durations: As required by design wind velocity, but not less than 10 seconds.
- F. Water Penetration under Static Pressure: Test in accordance with ASTM E331 as follows:
1. No evidence of water penetration through fixed glazing and framing areas when tested in accordance with a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).
- G. Water Penetration under Dynamic Pressure: Test in accordance with AAMA 501.1 as follows:
1. No evidence of water penetration through fixed glazing and framing areas when tested at dynamic pressure equal to 20 percent of positive wind-load design pressure, but not less than 6.24 lbf/sq. ft. (300 Pa).
 2. Maximum Water Leakage: In accordance with AAMA 501.1. Water leakage does not include water controlled by flashing and gutters, or water that is drained to exterior.

- H. Energy Performance: Certified and labelled by manufacturer for energy performance as follows:
1. Thermal Transmittance (U-factor):
 - a. Fixed Glazing and Framing Areas: U-factor for the system of not more than [0.41 Btu/sq. ft. x h x deg F (2.33 W/sq. m x K)] [0.45 Btu/sq. ft. x h x deg F (2.55 W/sq. m x K)] [0.57 Btu/sq. ft. x h x deg F (3.23 W/sq. m x K)] [0.69 Btu/sq. ft. x h x deg F (3.92 W/sq. m x K)] **<Insert value>** as determined in accordance with NFRC 100.
 - b. Venting Windows: Whole window U-factor of not more than [0.37 Btu/sq. ft. x h x deg F (2.10 W/sq. m x K)] [0.43 Btu/sq. ft. x h x deg F (2.44 W/sq. m x K)] [0.45 Btu/sq. ft. x h x deg F (2.55 W/sq. m x K)] [0.60 Btu/sq. ft. x h x deg F (3.40 W/sq. m x K)] [0.65 Btu/sq. ft. x h x deg F (3.69 W/sq. m x K)] **<Insert value>** as determined in accordance with NFRC 100.
 2. Solar Heat Gain Coefficient (SHGC):
 - a. Fixed Glazing and Framing Areas: SHGC for the system of not more than [0.26] [0.35] [0.40] [0.45] **<Insert value>** as determined in accordance with NFRC 200.
 - b. Venting Windows: Whole window SHGC of not more than [0.22] [0.27] [0.30] [0.40] **<Insert value>** as determined in accordance with NFRC 200.
 3. Air Leakage:
 - a. Fixed Glazing and Framing Areas: Air leakage for the system of not more than [0.06 cfm/sq. ft. (0.30 L/s per sq. m)] **<Insert value>** at a static-air-pressure differential of [1.57 lbf/sq. ft. (75 Pa)] [6.24 lbf/sq. ft. (300 Pa)] **<Insert value>** when tested in accordance with ASTM E283.
 - b. Venting Windows: Whole window air leakage of not more than [0.3 cfm/sq. ft. (0.30 L/s per sq. m)] **<Insert value>** at a static-air-pressure differential of [6.24 lbf/sq. ft. (300 Pa)] **<Insert value>** when tested in accordance with AAMA/WDMA/CSA 101/I.S.2/A440.
 4. Condensation Resistance: Design the wall and its components to not develop any visible interior condensation on framing members or glazing when the exterior air dry bulb temperature is **<insert value>** degrees F (**<insert value>** degrees C) and the interior air dry bulb temperature is **<insert value>** degrees F (**<insert value>** degrees C) with a **<insert value>** percent relative humidity.
 5. Condensation Resistance Factor (CRF):
 - a. Fixed Glazing and Framing Areas: CRF for the system of not less than [35] [55] [70] **<Insert value>** as determined in accordance with AAMA 1503.
 - b. Venting Windows: Whole window CRF of not less than [45] [52] [55] **<Insert value>** as determined in accordance with AAMA 1503.
- I. Noise Reduction: Test in accordance with ASTM E90, with ratings determined by ASTM E1332, as follows.
1. Outdoor-Indoor Transmission Class: Minimum [26] [30] [34] **<Insert number>**.
- J. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes.
1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 2. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested in accordance with AAMA 501.5.
 - a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of 180 deg F (82 deg C).
 - b. Low Exterior Ambient-Air Temperature: 0 deg F (minus 18 deg C).

c. Interior Ambient-Air Temperature: [75 deg F (24 deg C)] <Insert temperature>.

K. Structural-Sealant Joints:

1. Designed to carry gravity loads of glazing.

L. Structural Sealant: ASTM C1184. Capable of withstanding tensile and shear stresses imposed by structural-sealant-glazed, aluminum-framed storefronts without failing adhesively or cohesively. When tested for preconstruction adhesion and compatibility, cohesive failure of sealant shall occur before adhesive failure.

1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.
2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate, because sealant-to-substrate bond strength exceeds sealant's internal strength.

2.3 ALUMINUM-FRAMED STOREFRONT SYSTEMS

A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.

1. Exterior Framing Construction: Thermally broken .
2. Glazing System: Retained mechanically with gaskets on four sides .
3. Glazing Plane: Front.
4. Finish: Color anodic finish .
5. Fabrication Method: Field-fabricated stick system.
6. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
7. Steel Reinforcement: As required by manufacturer.

B. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction.

C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.

2.4 GLAZING

A. Glazing: Comply with Section 08 8000 "Glazing."

2.5 MATERIALS

A. Sheet and Plate: ASTM B209 (ASTM B209M).

B. Extruded Bars, Rods, Profiles, and Tubes: ASTM B221 (ASTM B221M).

C. Structural Profiles: ASTM B308/B308M.

D. Steel Reinforcement:

1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
3. Hot-Rolled Sheet and Strip: ASTM A1011/A1011M.

- E. Steel Reinforcement Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods in accordance with recommendations in SSPC-SP COM, and prepare surfaces in accordance with applicable SSPC standard.
- F. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] <Insert value> percent.
- G. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] [50] <Insert value> percent.
- H. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.

2.6 ACCESSORIES

- A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
 - 1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
 - 2. Reinforce members as required to receive fastener threads.
 - 3. Use exposed fasteners with countersunk Phillips screw heads[, **finished to match framing system**][, **fabricated from 300 series stainless steel**].
- B. Anchors: Three-way adjustable anchors with minimum adjustment of [1 inch (25.4 mm)] <Insert dimension> that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.
 - 1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A123/A123M or ASTM A153/A153M requirements.
- C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials .

2.7 FABRICATION

- A. Form or extrude aluminum shapes before finishing.
- B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- C. Fabricate components that, when assembled, have the following characteristics:
 - 1. Profiles that are sharp, straight, and free of defects or deformations.
 - 2. Accurately fitted joints with ends coped or mitered.
 - 3. Physical and thermal isolation of glazing from framing members.
 - 4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
 - 5. Provisions for field replacement of glazing from [exterior] [interior] [interior for vision glass and exterior for spandrel glazing or metal panels].

- 6. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
 - D. Mechanically Glazed Framing Members: Fabricate for flush glazing without projecting stops.
 - E. Storefront Framing: Fabricate components for assembly using [**shear-block system**] [**screw-spline system**] [**head-and-sill-receptor system with shear blocks at intermediate horizontal members**] <Insert system>.
 - F. After fabrication, clearly mark components to identify their locations in Project in accordance with Shop Drawings.
- 2.8 ALUMINUM FINISHES
- A. Color Anodic Finish: AAMA 611, AA-M12C22A32/A34, Class II, 0.010 mm or thicker.
 - 1. Color: Dark bronze .
- 2.9 SOURCE QUALITY CONTROL
- A. Structural Sealant: Perform quality-control procedures complying with ASTM C1401 recommendations, including, but not limited to, assembly material qualification procedures, sealant testing, and assembly fabrication reviews and checks.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Comply with manufacturer's written instructions.
- B. Do not install damaged components.
- C. Fit joints to produce hairline joints free of burrs and distortion.
- D. Rigidly secure nonmovement joints.
- E. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
- F. Seal perimeter and other joints watertight unless otherwise indicated.
- G. Metal Protection:
 - 1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.

2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
- H. Set continuous sill members and flashing in full sealant bed, as specified in Section 07 9200 "Joint Sealants," to produce weathertight installation.
- I. Install joint filler behind sealant as recommended by sealant manufacturer.
- J. Install components plumb and true in alignment with established lines and grades.

3.3 INSTALLATION OF GLAZING

- A. Install glazing as specified in Section 08 8000 "Glazing."

3.4 INSTALLATION OF WEATHERSEAL SEALANT

- A. After structural sealant has completely cured, remove temporary retainers and insert backer rod between lites of glass as recommended by sealant manufacturer.
- B. Install weatherseal sealant to completely fill cavity, in accordance with sealant manufacturer's written instructions, to produce weatherproof joints.

3.5 ERECTION TOLERANCES

- A. Install aluminum-framed storefronts to comply with the following maximum tolerances:
 1. Plumb: 1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
 2. Level: 1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).
 3. Alignment:
 - a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch (12.7 mm) wide, limit offset from true alignment to 1/16 inch (1.6 mm).
 - b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch (12.7 to 25.4 mm) wide, limit offset from true alignment to 1/8 inch (3.2 mm).
 - c. Where surfaces are separated by reveal or protruding element of 1 inch (25.4 mm) wide or more, limit offset from true alignment to 1/4 inch (6 mm).
 4. Location: Limit variation from plane to 1/8 inch in 12 feet (3.2 mm in 3.6 m); 1/2 inch (12.7 mm) over total length.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Field Quality-Control Testing: Perform the following test on representative areas of aluminum-framed storefronts.
 1. Water-Spray Test: Before installation of interior finishes has begun, areas designated by Architect shall be tested in accordance with AAMA 501.2 and shall not evidence water penetration.
 - a. Perform a minimum of three tests in areas as directed by Architect.
 2. Air Leakage: ASTM E783 at 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article but not more than 0.09 cfm/sq. ft. (0.45 L/s per sq. m) at a static-air-pressure differential of 1.57 lbf/sq. ft. (75 Pa).
 - a. Perform a minimum of three tests in areas as directed by Architect.

3. Water Penetration: ASTM E1105 at a minimum [**uniform**] [**and**] [**cyclic**] static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft. (300 Pa), and shall not evidence water penetration.
- C. Aluminum-framed storefronts will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

FOR REFERENCE ONLY

SECTION 08 4400 - GLAZED CURTAIN WALLS**PART 1 - GENERAL****1.1 SUMMARY****A. Section includes:**

1. X121 - Stick Built Assembly, 2-Sided Horizontal Structural Sealant Glazed, Aluminum Frame
2. X131 - Stick Built Assembly, 2-Sided Vertical Structural Sealant Glazed, Aluminum Frame
3. X151 - Stick Built Assembly, 4-Sided Captured, Aluminum Frame
4. X211 - Factory Glazed Unitized Assembly, 4-Sided Structural Sealant Glazed, Aluminum Frame
5. X221 - Factory Glazed Unitized Assembly, 2-Sided Horizontal Structural Sealant Glazed, Aluminum Frame
6. X231 - Factory Glazed Unitized Assembly, 2-Sided Vertical Structural Sealant Glazed, Aluminum Frame
7. X241 - Factory Glazed Unitized Assembly, Structural Sealant Glazed and Captured, Aluminum Frame
8. X251 - Factory Glazed Unitized Assembly, 4-Sided Captured, Aluminum Frame
9. X311 - Factory Glazed Cassette Assembly, 4-Sided Structural Sealant Glazed, Aluminum Frame
10. X321 - Factory Glazed Cassette Assembly, 2-Sided Horizontal Structural Sealant, Aluminum Frame
11. X331 - Factory Glazed Cassette Assembly, 2-Sided Vertical Structural Sealant Glazed, Aluminum Frame
12. X341 - Factory Glazed Cassette Assembly, Structural Sealant Glazed and Captured, Aluminum Frame
13. X351 - Factory Glazed Cassette Assembly, 4-Sided Captured, Aluminum Frame

B. Related Requirements:

1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
2. Section 01 4339 "Mockups" for preconstruction laboratory mockup testing.
3. Section 01 9119.43 "Exterior Enclosure Commissioning."
4. Section 05 1200 "Structural Steel"
5. Section 05 4000 "Cold Formed Metal Framing"
6. Section 05 5000 "Metal Fabrications".
7. Section 07 4210.11 "Composite Framing Support System"
8. Section 07413.16 "Metal Plate Wall Panels"
9. Section 07 8443 "Joint Firestopping" for perimeter fire-containment systems field installed with structural-sealant-glazed curtain walls.
10. Section 07 9200 "Joint Sealants" for installation of joint sealants installed with glazed aluminum curtain walls and for sealants to the extent not specified in this Section.
11. Section 08 4433 "Sloped Glazing Assemblies" for sloped glazing.
12. Section 08 8000 "Glazing."
13. **<Insert Section>**

1.2 DEFINITIONS

A. Water Penetration:

1. Water retained within the wetzone of the system without means of drainage is a failure.
2. Water leakage to the interior of the building which is not controlled by a weep/drainage system that is integral to the fenestration system is a failure.
3. Water observed on interior surfaces of the fenestration system is a failure.
4. Water observed on adjacent wall systems, originating from the fenestration system or the transition to the adjacent wall system, is a failure.

1.3 ALLOWANCES

- A. [Preconstruction laboratory mockup] [Source quality-control] [and] [field quality-control] testing is part of testing and inspecting allowance.

1.4 PRE-FABRICATION MEETINGS

A. Pre-fabrication Meeting: Conduct each meeting at **[Project site]** <Insert location>.

1. Meeting shall be held at least four weeks prior to fabrication of curtain wall system. Arrange meeting at fabrication or Project site with the glazier, sealant, and gasket manufacturers' technical representatives and any others necessary to review procedures, products to be used, and schedule for the Work. Give at least two weeks notice to Architect and other concerned parties.
2. Discuss Laboratory Mockup Testing Procedures.
3. Discuss Shop QAQC procedures.
4. Discuss substrates to be sealed, discuss as fabricated and installed condition of substrate, sealant application, flashing details, and other preparatory work.
5. Review joint sealant requirements: drawings, specifications, and other contract documents.
6. Review joint sealant testing, types, primers, and substrates.
7. Review required submittals, both complete and incomplete.
8. Review weather and forecasted weather conditions and procedures for working with unfavorable conditions.
9. Review schedule and intended sequence of work.
10. Review the purpose and method of integration of field quality assurance programs developed by Contractor and suppliers/subcontractors responsible for the Work.
11. Review purpose and method of integration of field quality assurance program administered by the Testing and Inspection Agency.

1.5 PREINSTALLATION MEETING

A. Preinstallation Meeting: Conduct each meeting at **[Project site]** <Insert location>.

1. Meeting shall be held at least two weeks prior to installation of curtain wall system. Arrange meeting(s) at fabrication or Project site with the Architect, Contractor, glazier, testing agency, sealant manufacturer's technical representative, and any others necessary to review procedures, products to be used, and schedule for the Work. Give at least two weeks notice to Architect and other concerned parties.
2. Discuss Field QAQC procedures.
3. Discuss substrates to be sealed, discuss as fabricated and installed condition of substrate, sealant application, flashing details, and other preparatory work.

4. Review joint sealant requirements: drawings, specifications, and other contract documents.
5. Review joint sealant testing, types, primers, and substrates.
6. Review transitions to adjacent exterior envelope assemblies.
7. Review required submittals, both complete and incomplete.
8. Review weather and forecasted weather conditions and procedures for working with unfavorable conditions.
9. Review schedule and intended sequence of work.
10. Review changes arising from the pre-construction mock-up and performance testing program.
11. Review the purpose and method of integration of field quality assurance programs developed by Contractor and suppliers/subcontractors responsible for the Work.
12. Review purpose and method of integration of field quality assurance program administered by the Testing and Inspection Agency.

1.6 ACTION SUBMITTALS

- A. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
 1. Provide delegated design submittals for the following:
 - a. For glazed aluminum curtain walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Include the following items, but not limited to, in the Delegated Design Submittal:
 - 1) Project [and Mockup] Shop Drawings
 - 2) Structural Calculations
 - 3) Demonstration of thermal movement accommodation
 - 4) Verification of meeting Deflection Criteria
 - 5) Energy Performance Submittals
 - 6) Thermal/Heat Stress Analysis
 - 7) Differential Shading Analysis
 - 8) Probability of Glass Breakage
 - 9) Accommodation for drainage of the System
 - 10) [Material test results]
 - 11) [Calculated Structural Sealant Glazing Dimensions]
 - 12) [Condensation Resistance Reports]
 - 13) [Acoustic Analysis]
 - 14) [Laboratory Test Reports for Mockup Testing]
 - 15) [Structural Sealant Test Reports and Approval from Manufacturer]
 - 16) [Noise or vibration control]
 - 17) [Rope Descent Facade Access Equipment Integration]
 - 18) [Implementation of BIPV and PV Fin]
- B. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required [Product Data submittal][and][Samples submittal]. Ensure compliance with requirements included in [Section 01 3300 "Submittal Procedures"] [Section 08 0413 "Common Submittal Requirements for Openings"].
- C. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
- D. Sustainable Design Submittals:
1. Product Data: For sealants, indicating VOC content.
 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
 3. Product Certificates: For materials manufactured within 100 miles (160 km) of Project, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each raw material.
 4. Product Certificates: For indigenous materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each indigenous material.
 5. Product Certificates: For regional materials, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project, means of transportation, and cost for each regional material.
 6. Environmental Product Declaration: For each product.
 7. Health Product Declaration: For each product.
 8. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 9. Environmental Product Declaration: For each product.
 10. Environmental Product Declaration: For each product.
 11. Environmental Product Declaration: For each product.
 12. Third-Party Certifications: For each product.
 13. Third-Party Certified Life Cycle Assessment: For each product.
- E. Product Test Reports: For glazed curtain walls, for tests performed by **[manufacturer and witnessed by a qualified testing agency] [a qualified testing agency]**. Based on evaluation of comprehensive tests performed by a qualified preconstruction testing agency, for glazed aluminum curtain walls, indicating compliance with performance requirements.
- F. Shop Drawings: For glazed curtain walls. Include project specific plans, elevations, sections, full-size details, transitions to adjacent enclosure assemblies, and attachments to other work.
1. Include details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
 2. Illustrate connection to and continuity with adjacent thermal, weather, air, and vapor barriers for other enclosure systems.
 3. Include full-size isometric details of each vertical-to-horizontal intersection of structural-sealant-glazed curtain walls, showing the following:
 - a. Joinery, including concealed welds.
 - b. Anchorage.
 - c. Expansion provisions.
 - d. Glazing.
 - e. Flashing and drainage.
 4. Details of weeping and venting of spandrel and shadowbox conditions.
 5. Include laboratory mockup Shop Drawings, prepared by a qualified preconstruction testing agency, showing details of laboratory mockup.
 - a. Submit mockup system Shop Drawings only after approval of wall system Shop Drawings.
 - b. Resubmit Shop Drawings with changes made to glazed aluminum curtain walls to successfully complete preconstruction testing.

6. Include Site Mockup Shop Drawings, prepared by a qualified preconstruction testing agency, showing details of laboratory mockup.
 - a. Submit mockup system Shop Drawings only after approval of wall system Shop Drawings.
 - b. Resubmit Shop Drawings with changes made to glazed aluminum curtain walls to successfully complete preconstruction testing.
 7. Include Deglaze / Reglaze procedures for each unique glazing unit type and associated obstructions.
- G. Engineering Calculations
1. Submit engineering calculations as described hereinafter and in the General Conditions.
 2. Engineering calculations shall be submitted concurrently with the corresponding shop drawings.
 3. All calculations shall bear the stamp of a professional engineer registered in the State of **[Insert State Name]**.
- H. Samples for Initial Selection: For units with factory-applied color finishes. Include 2 or more samples in each set, indicating limits of variation.
- I. Samples for Verification: For each type of exposed finish required, in manufacturer's standard sizes.
- J. Fabrication Sample: Of each vertical-to-horizontal intersection of assemblies, made from 12-inch (300-mm) lengths of full-size components and showing details of the following:
1. Joinery, including concealed welds.
 2. Anchorage.
 3. Expansion provisions.
 4. Glazing.
 5. Flashing and drainage.
 6. Cross-sectional sample of curtain wall showing thermal break construction.
- K. Samples of Terra Cotta for color range approval.
- L. Samples of the Aluminum Fins and attachment device.
- M. Samples of **[insert other components that require samples]**.
- N. Preconstruction Site and Laboratory Mockup Testing Submittals:
1. Testing Program: Developed specifically for Project that includes the testing agencies preconstruction testing sequence for **[Laboratory]** **[and Site Mockup]** Testing.
 2. Test Reports: Prepared by a qualified preconstruction testing agency for each mockup test. Test and performance data shall be dated no later than one year earlier than the date for receipt of bids.
 - a. Laboratory Test reports older than one year may be acceptable if certified by the manufacturer that no changes, alterations or modifications have occurred that would materially affect the performance values or performance of the system.
 3. Record Drawings: As-built drawings of preconstruction laboratory mockups showing changes made during preconstruction laboratory mockup testing.
 4. Photographs:
 - a. Take a photographs at locations and intervals as required by Architect.

- b. Submit digital color images of mockup before, during, and after preconstruction testing.
- O. Site Testing Submittals:
 - 1. Testing Program: Developed specifically for Project that includes the testing agencies testing sequence and test plan for each test location.
 - 2. Test Reports: Prepared by a qualified preconstruction testing agency for each test.
 - 3. Photographs:
 - a. Take a photographs at locations and intervals as required by Architect.
 - b. Submit digital color images before, during, and after testing.
- P. Condensation Resistance Reports: Provide a report that demonstrates all curtain wall assemblies are capable of meeting the performance requirements.
 - 1. Provide computer analysis using THERM and Windows software as developed by Lawrence Berkeley National Laboratory.
 - 2. Include in the analysis and report all typical mullions, such as but not limited to, sill, jamb, and head, intermediate horizontal mullion, and intermediate vertical mullion conditions for vision, spandrel, and shadow box areas for each curtain wall type.
 - a. The number of conditions required to be included in the analysis may be reduced if the following information is provided:
 - 1) An engineering evaluation that demonstrates the conditions included in the analysis will perform worse than the conditions proposed to not be included.
 - b. The analysis and engineering evaluation must be performed by experts experienced in hygrothermal analysis of fenestration assemblies utilizing appropriate engineering means of analysis.
 - c. The analysis must be signed and sealed by an professional engineer.
 - 3. Include the transition to adjacent enclosure assemblies in the thermal models.
 - a. The extent of the adjacent enclosure assembly to include in the model:
 - 1) 12 inches minimum, or
 - 2) as determined by where the isothermal lines obtain a uniform pattern.
 - 4. Include models for each curtain wall assembly at all adjacent exterior enclosure assemblies.
 - 5. Include the following information in the submitted report:
 - a. Component Material color legend
 - b. Image of THERM Model viewed with isotherm overlay.
 - c. Image of THERM Model viewed with infrared overlay.
 - d. Image and detail number of Corresponding Architectural Reference Detail
 - e. Indication of multiple temperatures on both model images.
 - f. Indication of the cold point temperature on both model images.
 - g. Indication of allowable dewpoint based on project specific requirements.
 - h. If the cold point temperature is below project specific dewpoint, then indicate the corresponding RH in which condensation would occur at the cold point temperature.
- Q. Energy Performance Submittals:
 - 1. Provide NFRC-certified approved label certificate.
 - 2. Provide U-factor calculations and results for each vision and opaque curtain wall type separately in compliance with NFRC 100.
 - a. Calculations shall take into account all thermal bridging elements including those that are discontinuous.

- R. Manufacturer's system and project specific installation instructions and glazing manual.
- S. Acoustical Test Report: Submit acoustical test results indicating the OITC rating of the curtain wall system (glass and frame).
 - 1. Test data shall be produced from an accredited independent acoustical laboratory.
 - 2. Reports shall indicate that the test was performed on the window assembly of the type to be supplied in conformance with the requirements of the test method.
- T. Quality Assurance / Quality Control (QA/QC) Program: Developed specifically for Project, including fabrication and installation, according to recommendations in ASTM C 1401. Include periodic quality-control reports.
 - 1. Provide a comprehensive project specific QA/QC program that conforms to the recommendations in ASTM C1401 developed specifically for this project that includes shop and installation procedures documented in a QA/QC manual printed on manufacturer's letterhead.
 - 2. Provide permanent individual labeling for each unit that includes traceable batch information for the materials used in the specific unit construction.
 - 3. Provide recorded documentation that is produced throughout the QA/QC program to the Owner.
 - 4. Provide periodic quality control reports.
 - 5. Include the following, but not limited to, in the QA/QC program / manual.
 - a. Storage conditions of materials and finished product.
 - b. Delivery of materials and finished product.
 - c. Confirmation of material tolerances and damages.
 - d. Example of Permanent Unit Labeling/Numbering system keyed to installation location on elevations including date and weather conditions when installed.
 - e. Sample production unit checklist that includes types and lot/batch information for each component.
 - f. Gasket installation methods.
 - g. IGU inspection.
 - h. IGU orientation.
 - i. Edge Deletion inspection.
 - j. Glass placement tolerances.
 - k. Cleaning procedures.
 - l. SSG spacer placement and SSG sealant profile verification.
 - m. Primer requirements and curing validation method.
 - n. Masking / Taping procedures for Primers and Sealants.
 - o. Shelf life of materials.
 - p. Method to ensure SSG does not bleed between glass and gaskets.
 - q. SSG cure time before moving units.
 - r. Temporary IGU retention during SSG installation.
 - s. Metal Backpan Sealant Installation.
 - t. Venting of Shadow Boxes.
 - u. Sealant joinery at penetrations through air/water line.
 - v. Periodic Shop Testing including frequency, test description, log of tests, and photo documentation.
 - 1) SSG Adhesion Test
 - 2) Weather Sealant Adhesion Test
 - 3) Butterfly Test
 - 4) Snap Test

- 5) Completed Unit Water Test
 - 6) Completed Unit Air Test
 - 7) Completed Unit Wind Load Test
 - w. Deglazing Procedures
 - 1) Minimum Frequency
 - a) 1 in first 10
 - b) 1 in next 40
 - c) 1 in next 50
 - d) 1 in 100 thereafter
 - 2) Log of Deglazing
 - 3) SSG inspection/testing.
 - a) Dimension of glass bite
 - b) Thickness of sealant
 - c) Adhesion testing
 - d) Bond profile
 - e) Bubbles/voids in the sealant profile
 - f) Sealant is installed full depth
 - g) Sealant is not squeezing out from the gasket plane
 - 4) Photo documentation.
 - x. Site dam/flood testing at stack joint / split vertical interface.
 - y. Site verification method for engagement of split vertical mullions.
 - z. Site verification of proper stack joint gasket final placement.
 - aa. Deglaze / Reglaze procedures for each unit type.
 - bb. Site verification of curtain wall anchor placement.
 - cc. Site verification of anti-walk clip installation.
 - U. Quality-Control Program: Developed specifically for Project, including fabrication and installation, in accordance with recommendations in ASTM C 1401 for design and installation of curtain wall assemblies. Include periodic quality-control reports.
 - V. Quality-Control Program: Developed specifically for Project, including fabrication and installation for design and installation of curtain wall assemblies. Include periodic quality-control reports.
 - W. Quality Assurance Submittals
 - 1. Qualification Data: For qualified Installer, Manufacturer, preconstruction testing agency, and testing agency.
 - 2. Seismic Qualification Certificates: For glazed aluminum curtain walls, accessories, and components, from manufacturer.
 - 3. Welding certificates.
 - 4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified preconstruction testing agency, for glazed aluminum curtain walls, indicating compliance with performance requirements.
 - 5. Source quality-control reports.
 - 6. Field quality-control reports.
- 1.7 CLOSEOUT SUBMITTALS
- A. Maintenance Data: For glazed curtain walls to include in maintenance manuals.

- B. Maintenance Data for Structural Sealant: For structural-sealant-glazed curtain walls to include in maintenance manuals. Include ASTM C 1401 recommendations for post installation-phase quality-control program.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: An entity capable of fabricating structural-sealant-glazed curtain wall systems that meet or exceed energy performance requirements indicated, and capable of documenting performance requirements by certification, labeling and inclusion lists.
- B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- C. Preconstruction Mockup Testing Agency Qualifications: Qualified in accordance with ASTM E 699 for testing indicated **[and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025]**.
- D. Testing Agency Qualifications: Qualified in accordance with ASTM E 699 for testing indicated **[and accredited by IAS or ILAC Mutual Recognition Arrangement as complying with ISO/IEC 17025]**.
- E. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.
 - 1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.
- F. Welding certificates.
 - 1. Welding Qualifications: Qualify procedures and personnel in accordance with the following.
 - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
- G. Structural-Sealant Glazing: Comply with ASTM C 1401 for design and installation of curtain-wall assemblies.
- H. Energy Performance Certificates:
 - 1. Comply with NFRC for minimum standards of energy performance, materials, components, accessories, and fabrication. Comply with more stringent requirements if indicated.
 - 2. Basis for Certification: NFRC-certified energy performance values for each glazed curtain wall type.

1.9 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service:
 - 1. **[Owner will engage] [Engage]** a qualified testing agency to perform preconstruction testing on mockups.

2. Build mockups using personnel, materials, and methods of construction that will be used at Project site.
- B. Preconstruction Laboratory Testing Requirements:
1. Provide glazed aluminum curtain walls that comply with test-performance requirements indicated, as evidenced by reports based on Project-specific preconstruction testing or previous laboratory testing performed on manufacturer's standard assemblies by a qualified testing agency.
 - a. The curtain wall assembly included in the previous Laboratory Testing is required to include identical components as the project specific details.
 - b. The previously tested laboratory test specimen is required to be of similar size and anchorage as the project specific conditions.
 - c. Test and performance data shall be dated no later than 1 year earlier than the date for receipt of bids.
 - d. Laboratory Test reports older than 1 year may be acceptable if certified by the manufacturer that no changes, alterations or modifications have occurred that would materially affect the performance values or performance of the system.
 - C. Pretesting: Testing prior to official testing by the Testing Agency is allowed provided a representative of the Testing Agency is present to witness the testing and documents the results. If modifications are required based on unsatisfactory test results, such modifications must be documented in a formal report and incorporated into the project documentation/submittals such as shop drawings, calculations, and/or quality control measures.
 1. This requirement applies to:
 - a. On-Building Performance Mockups
 - b. Off-Building Onsite Performance Mockups
 - c. Preconstruction Laboratory Mockups
- 1.10 MOCKUPS
- A. Mockups shall have all details complete and identical to those approved on the wall system shop drawings. Mockup shall demonstrate quality of materials, finish, and workmanship, as well as compliance with performance requirements.
 - B. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit owner and Architect to coordinate monitoring and observation.
 - C. Comply with **[Section 01 4339 "Exterior Wall Mockups"] [Section 01 4339.13 "Exterior Wall Enclosure Assembly Mockup and Testing"]**.
 - D. Visual Mockup:
 1. Visual Mockups are constructed to demonstrate aesthetic effects and are composed from the approved "Samples for Initial Selection" submittal process. The materials on this Mockup will serve as "Samples for Verification".
 2. Prior to ordering exterior materials and prior to commencing exterior construction, build a freestanding Visual Mockup that includes exterior materials. Coordinate installation of exterior envelope materials and products for which mockups are required along with supporting materials.
 - a. Mockup Size:
 - 1) Panel Size: As indicated on Drawings.

- 2) Individual Sample Size: As indicated on Drawings.
 - b. Sample Materials to include on Visual Mockup: As indicated on Drawings.
 - c. Review Process and Timing:
 - 1) Approve mockup prior to ordering final building materials.
 - d. Allow for time to review alternate materials.
 - e. Allow for time in the event materials are rejected and require resubmission and approval.
 - f. Locate the mockup panel such that it remains on-site in the same location through the duration of construction until the first certificate of occupancy.
- E. On-Building Performance Mockups: Build mockups to set quality standards for fabrication and installation, and for onsite performance testing. Mockup shall demonstrate quality of materials, finish, tolerances, and workmanship, as well as compliance with performance requirements.
- 1. Furnish all labor and materials to completely erect mockup unit[s] of sufficient size and configuration to demonstrate the performance capabilities of the vertical wall system. Schedule mockup erection and testing sufficiently in advance of wall system fabrication to cause no delay.
 - 2. Ensure that transitions to adjacent exterior envelope assemblies are complete and have had adequate time to cure prior to testing.
 - 3. After completion of mockup construction and prior to start of testing sequence **[one] [two]** vision glass lite[s] **[and] [one] [two] [spandrel panels]** are to be removed and replaced to successfully demonstrate project reglazing procedures.
 - 4. Build mockup of typical wall area as shown on Drawings.
 - a. Exact configuration will be determined during wall system shop drawing review. For purposes of bidding, include costs for a vertical mockup **<Insert number>** feet (**<Insert number>** meters) high by **<Insert number>** feet (**<Insert number>** meters) wide with an **[inside] [and] [outside]** corner.
 - b. Mockup shall have all details complete and identical to those approved on the wall system shop drawings. Mockup shall demonstrate quality of materials, finish, and workmanship, as well as compliance with performance requirements.
 - 5. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit owner and Architect to coordinate monitoring and observation.
 - 6. Notify Architect **[seven] <Insert number>** days in advance of the dates and times when construction mockups will be constructed and tested.
 - 7. Testing shall be performed on mockups in accordance with requirements in "Field Quality Control" Article.
 - a. In the event of failure to meet the performance requirements:
 - b. Determine Cause of Failure.
 - c. Provide a remediation plan for review prior to performing the remediation and retesting.
 - d. Repair per manufacturer's recommendations.
 - e. Retest mockup with previously agreed upon modifications or changes.
 - f. The Architect in consultation with the testing service will determine at which step in the testing procedure retesting shall resume.
 - g. Incorporate agreed upon modifications into project submittals for record.
 - h. If Cause of Failure was due to issues related to the quality of installation or failure to follow installation instructions or shop drawings, incorporate method to ensure future compliance into the fabrication and installation quality assurance and control programs.

- i. All fees and expenses incurred by the Owner associated with the participation of the Architect, Owner, and Owner's designated technical representatives to observe both the repair/reconstruction of the mock-up, re-testing of same mockup, in whole or in part, shall be the sole responsibility of the Contractor.
 - 8. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 9. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- F. Off-Building Onsite Performance Mockups: Build mockups to **[verify selections made under Sample submittals], [to demonstrate aesthetic effects]**, set quality standards for fabrication and installation, and for onsite performance testing. Mockup shall demonstrate quality of materials, finish, tolerances, and workmanship, as well as compliance with performance requirements.
- 1. Furnish all labor and materials to completely erect mockup unit[s] of sufficient size and configuration to demonstrate the performance capabilities of the wall system. Schedule mockup erection and testing sufficiently in advance of wall system fabrication to cause no delay. Do not install mockup materials as part of the wall system.
 - 2. After completion of mockup construction and prior to start of testing sequence, remove and reinstall **[one] [two]** vision glass lite[s] **[and] [one] [two] [spandrel panel][s]** to successfully demonstrate project reglazing procedures.
 - 3. Build mockup of typical wall area as shown on Drawings.
 - a. Exact configuration will be determined during wall system shop drawing review.
 - b. Mockup shall have all details complete and identical to those approved on the wall system shop drawings.
 - 4. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit owner and Architect to coordinate monitoring and observation.
 - 5. Notify Architect **[seven] <Insert number>** days in advance of the dates and times when construction mockups will be constructed and tested.
 - 6. Testing shall be performed on mockups in accordance with requirements in "Field Quality Control" Article.
 - a. In the event of failure to meet the performance requirements:
 - 1) Determine Cause of Failure.
 - 2) Provide a remediation plan for review prior to performing the remediation and retesting.
 - 3) Repair per manufacturer's recommendations.
 - 4) Retest mockup with previously agreed upon modifications or changes.
 - 5) The Architect in consultation with the testing service will determine at which step in the testing procedure retesting shall resume.
 - 6) Incorporate agreed upon modifications into project submittals for record.
 - 7) If Cause of Failure was due to issues related to the quality of installation or failure to follow installation instructions or shop drawings, incorporate method to ensure future compliance into the fabrication and installation quality assurance and control programs.
 - 8) All fees and expenses incurred by the Owner associated with the participation of the Architect, Owner, and Owner's designated technical representatives to observe both the repair/reconstruction of the mock-up, re-testing of same mockup, in whole or in part, shall be the sole responsibility of the Contractor.

7. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
8. Locate the mockup such that it remains on-site in the same location through the duration of construction until the first certificate of occupancy.

G. Preconstruction Laboratory Mockups:

1. Build mockups to **[verify selections made under Sample submittals], [to demonstrate aesthetic effects]**, set quality standards for fabrication and installation, and for performance testing. Mockup shall demonstrate quality of materials, finish, tolerances, and workmanship, as well as compliance with performance requirements.
 - a. Furnish all labor and materials to completely erect mockup unit[s] of sufficient size and configuration to demonstrate the performance capabilities of the wall system. Schedule mockup erection and testing sufficiently in advance of wall system fabrication to cause no delay. Do not install mockup materials as part of the wall system.
 - b. After completion of mockup construction and prior to start of testing sequence, remove and reinstall **[one] [two]** vision glass lite[s] **[and] [one] [two] [spandrel panel][s]** to successfully demonstrate project reglazing procedures.
 - c. Build mockup of typical wall area as shown on Drawings.
 - 1) Exact configuration will be determined during wall system shop drawing review.
 - 2) Mockup shall have all details complete and identical to those approved on the wall system shop drawings.
 - 3) Build preconstruction laboratory mockups at testing agency facility; use personnel, products, and methods of construction that will be used at Project site.
 - d. Provide schedule for mockup fabrication, erection, glazing, sealing and testing a minimum of 30 days in advance of fabrication to permit owner and Architect to coordinate monitoring and observation.
 - e. Notify Architect **[seven] <Insert number>** days in advance of the dates and times when preconstruction laboratory mockups will be constructed and tested.
2. Preconstruction Testing Service: **[Owner will engage] [Engage]** a qualified testing agency to perform testing on preconstruction laboratory mockups.
3. Preconstruction Laboratory Mockup Testing Program: Test preconstruction laboratory mockups in accordance with requirements in "Performance Requirements" Article. Perform the following tests in the following order:
 - a. Structural: ASTM E 330 at 50 percent of positive test load.
 - b. Air Infiltration: ASTM E 283.
 - c. Water Penetration under Static Pressure: ASTM E 331.
 - d. Water Penetration under Dynamic Pressure: AAMA 501.1.
 - e. Structural: ASTM E 330 at 100 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - e) Deflections in excess of those specified are not acceptable.
 - f. Water Penetration under Static Pressure: ASTM E 331.

- g. Interstory Drift: AAMA 501.4 at 100 percent of design displacement (elastic movement) in 4 directions.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
- h. Water Penetration under Static Pressure: ASTM E 331.
- i. Vertical Interstory Movement: AAMA 501.7 at design displacement.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - 2) Maintain the test specimen at the maximum open joint position for the balance of testing.
- j. Water Penetration under Static Pressure: ASTM E 331.
- k. Water Penetration under Dynamic Pressure: AAMA 501.1.
- l. Structural: ASTM E 330 at 150 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout or breakage.
 - b) Components cannot fall off.
 - c) Permanent damage to panels is not allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Permanent deformation to wall framing members not to exceed 0.2 percent of the clear span.
 - f) Trim can be disengaged but cannot fall off.
- m. Interstory Drift: AAMA 501.4 at inelastic design displacement in 4 directions.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout.
 - b) Components cannot fall off.
 - c) Visible damage and minor distortion is allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Trim can be disengaged but cannot fall off.
- 4. Preconstruction Laboratory Mockup Testing Program: Test preconstruction laboratory mockups in accordance with requirements in "Performance Requirements" Article. Perform the following tests in the following order:
 - a. Structural: ASTM E 330 at 50 percent of positive test load.
 - b. Air Infiltration: ASTM E 283.
 - c. Water Penetration under Static Pressure: ASTM E 331.
 - d. Water Penetration under Dynamic Pressure: AAMA 501.1.
 - e. Structural: ASTM E 330 at 100 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.

- d) Components cannot fall off. Trim cannot be disengaged.
 - e) Deflections in excess of those specified are not acceptable.
- f. Water Penetration under Static Pressure: ASTM E 331.
- g. Interstory Drift: AAMA 501.4 at 100 percent of design displacement (elastic movement) in 4 directions.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
- h. Water Penetration under Static Pressure: ASTM E 331.
- i. Vertical Interstory Movement: AAMA 501.7 at design displacement.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - 2) Maintain the test specimen at the maximum open joint position for the balance of testing.
- j. Water Penetration under Static Pressure: ASTM E 331.
- k. Periodic Maintenance Equipment Load (Continuous Tie-in Guides):
 - 1) Apply <insert load> normal to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 2) Apply <insert load> horizontally parallel to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 3) Failure Criteria:
 - a) There shall be no permanent deformation of the anchorage connector.
 - b) There shall be no permanent deformation of the glazed curtain wall assembly.
 - c) No glass breakage or glass fallout is allowed.
 - d) Post displacement performance testing remains within specified requirements.
 - e) Components cannot fall off. Trim cannot be disengaged.
- l. Periodic Maintenance-Equipment Load (Intermittent Stabilization):
 - 1) Apply <insert load> side load (parallel to plane of wall) in all four directions (left, right, up, and down).
 - 2) Apply <insert load> outward load (perpendicular to the plane of the wall).
 - 3) Failure Criteria:
 - a) There shall be no permanent deformation of the anchorage connector.
 - b) There shall be no permanent deformation of the glazed curtain wall assembly.
 - c) No glass breakage or glass fallout is allowed.
 - d) Post displacement performance testing remains within specified requirements.
 - e) Components cannot fall off. Trim cannot be disengaged.
- m. Water Penetration under Static Pressure: ASTM E 331.
- n. Water Penetration under Dynamic Pressure: AAMA 501.1.
- o. Structural: ASTM E 330 at 150 percent of positive and negative test loads.
 - 1) Failure Criteria:

- a) Glass is retained completely in the glazed opening with no glass fallout or breakage.
 - b) Components cannot fall off.
 - c) Permanent damage to panels is not allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Permanent deformation to wall framing members not to exceed 0.2 percent of the clear span.
 - f) Trim can be disengaged but cannot fall off.
- p. Interstory Drift: AAMA 501.4 at inelastic design displacement in 4 directions.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout.
 - b) Components cannot fall off.
 - c) Visible damage and minor distortion is allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Trim can be disengaged but cannot fall off.
- q. Periodic Maintenance Equipment Overload (Continuous Tie-in Guides):
 - 1) Apply <insert load> normal to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 2) Apply <insert load> horizontally parallel to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 3) Failure Criteria:
 - a) The anchorage connector shall not detach.
 - b) Components of the glazed curtain wall assembly shall not detach.
 - c) Glass is retained completely in the glazed opening with no glass fallout.
- r. Periodic Maintenance-Equipment Overload (Intermittent Stabilization):
 - 1) Apply <insert load> side load (parallel to plane of wall) in all four directions (left, right, up, and down).
 - 2) Apply <insert load> outward load (perpendicular to the plane of the wall).
 - 3) Failure Criteria:
 - a) The anchorage connector shall not detach.
 - b) Components of the glazed curtain wall assembly shall not detach.
 - c) Glass is retained completely in the glazed opening with no glass fallout.
- 5. Preconstruction Laboratory Mockup Testing Program: Test preconstruction laboratory mockups in accordance with requirements in "Performance Requirements" Article. Perform the following tests in the following order:
 - a. Structural: ASTM E 330 at 50 percent of positive test load.
 - b. Air Infiltration: ASTM E 283.
 - c. Thermal Cycling: According to AAMA 501.5.
 - d. Air Infiltration: ASTM E 283.
 - e. Water Penetration under Static Pressure: ASTM E 331.
 - f. Water Penetration under Dynamic Pressure: AAMA 501.1.
 - g. Structural: ASTM E 330 at 100 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - 2) All functions remain unimpaired with no visible damage.
 - 3) No glass breakage or glass fallout is allowed.
 - 4) Post displacement performance testing remains within specified requirements.
 - 5) Components cannot fall off. Trim cannot be disengaged.

- 6) Deflections in excess of those specified are not acceptable.
- h. Water Penetration under Static Pressure: ASTM E 331.
- i. Interstory Drift: AAMA 501.4 at 100 percent of design displacement (elastic movement) in 4 directions.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
- j. Water Penetration under Static Pressure: ASTM E 331.
- k. Vertical Interstory Movement: AAMA 501.7 at design displacement.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - 2) Maintain the test specimen at the maximum open joint position for the balance of testing.
- l. Water Penetration under Static Pressure: ASTM E 331.
- m. Water Penetration under Dynamic Pressure: AAMA 501.1.
- n. Structural: ASTM E 330 at 150 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout or breakage.
 - b) Components cannot fall off.
 - c) Permanent damage to panels is not allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Permanent deformation to wall framing members not to exceed 0.2 percent of the clear span.
 - f) Trim can be disengaged but cannot fall off.
- o. Interstory Drift: AAMA 501.4 at inelastic design displacement in 4 directions.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout.
 - b) Components cannot fall off.
 - c) Visible damage and minor distortion is allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Trim can be disengaged but cannot fall off.
- 6. Preconstruction Laboratory Mockup Testing Program: Test preconstruction laboratory mockups in accordance with requirements in "Performance Requirements" Article. Perform the following tests in the following order:
 - a. Structural: ASTM E 330 at 50 percent of positive test load.
 - b. Air Infiltration: ASTM E 283.
 - c. Thermal Cycling: According to AAMA 501.5.
 - d. Air Infiltration: ASTM E 283.
 - e. Water Penetration under Static Pressure: ASTM E 331.
 - f. Water Penetration under Dynamic Pressure: AAMA 501.1.
 - g. Structural: ASTM E 330 at 100 percent of positive and negative test loads.
 - 1) Failure Criteria:

- a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - e) Deflections in excess of those specified are not acceptable.
- h. Water Penetration under Static Pressure: ASTM E 331.
- i. Interstory Drift: AAMA 501.4 at 100 percent of design displacement (elastic movement) in 4 directions.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
- j. Water Penetration under Static Pressure: ASTM E 331.
- k. Vertical Interstory Movement: AAMA 501.7 at design displacement.
 - 1) Failure Criteria:
 - a) All functions remain unimpaired with no visible damage.
 - b) No glass breakage or glass fallout is allowed.
 - c) Post displacement performance testing remains within specified requirements.
 - d) Components cannot fall off. Trim cannot be disengaged.
 - 2) Maintain the test specimen at the maximum open joint position for the balance of testing.
- l. Water Penetration under Static Pressure: ASTM E 331.
- m. Periodic Maintenance Equipment Load (Continuous Tie-in Guides):
 - 1) Apply <insert load> normal to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 2) Apply <insert load> horizontally parallel to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 3) Failure Criteria:
 - a) There shall be no permanent deformation of the anchorage connector.
 - b) There shall be no permanent deformation of the glazed curtain wall assembly.
 - c) No glass breakage or glass fallout is allowed.
 - d) Post displacement performance testing remains within specified requirements.
 - e) Components cannot fall off. Trim cannot be disengaged.
- n. Periodic Maintenance-Equipment Load (Intermittent Stabilization):
 - 1) Apply <insert load> side load (parallel to plane of wall) in all four directions (left, right, up, and down).
 - 2) Apply <insert load> outward load (perpendicular to the plane of the wall).
 - 3) Failure Criteria:
 - a) There shall be no permanent deformation of the anchorage connector.
 - b) There shall be no permanent deformation of the glazed curtain wall assembly.
 - c) No glass breakage or glass fallout is allowed.
 - d) Post displacement performance testing remains within specified requirements.
 - e) Components cannot fall off. Trim cannot be disengaged.

- o. Water Penetration under Static Pressure: ASTM E 331.
- p. Water Penetration under Dynamic Pressure: AAMA 501.1.
- q. Structural: ASTM E 330 at 150 percent of positive and negative test loads.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout or breakage.
 - b) Components cannot fall off.
 - c) Permanent damage to panels is not allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Permanent deformation to wall framing members not to exceed 0.2 percent of the clear span.
 - f) Trim can be disengaged but cannot fall off.
- r. Interstory Drift: AAMA 501.4 at inelastic design displacement in 4 directions.
 - 1) Failure Criteria:
 - a) Glass is retained completely in the glazed opening with no glass fallout.
 - b) Components cannot fall off.
 - c) Visible damage and minor distortion is allowed.
 - d) Do not evidence material failures or structural distress.
 - e) Trim can be disengaged but cannot fall off.
- s. Periodic Maintenance Equipment Overload (Continuous Tie-in Guides):
 - 1) Apply <insert load> normal to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 2) Apply <insert load> horizontally parallel to the plane of the wall (<insert value> times of equipment load plus 1/3 of inward acting design wind load).
 - 3) Failure Criteria:
 - a) The anchorage connector shall not detach.
 - b) Components of the glazed curtain wall assembly shall not detach.
 - c) Glass is retained completely in the glazed opening with no glass fallout.
- t. Periodic Maintenance Equipment Overload (Intermittent Stabilization):
 - 1) Apply <insert load> side load (parallel to plane of wall) in all four directions (left, right, up, and down).
 - 2) Apply <insert load> outward load (perpendicular to the plane of the wall).
 - 3) Failure Criteria:
 - a) The anchorage connector shall not detach.
 - b) Components of the glazed curtain wall assembly shall not detach.
 - c) Glass is retained completely in the glazed opening with no glass fallout.
- u. Glass Delta Fallout Displacement: AAMA 501.6 at design level lateral story displacement x 1.25 x 1.5 (ASCE 7-05 Section 13.5.9.1, Eqn. 13.5-1).
- 7. In the event of failure to meet the performance requirements:
 - a. Determine Cause of Failure.
 - b. Provide a remediation plan for review prior to performing the remediation and retesting.
 - c. Repair per manufacturer's recommendations.
 - d. Retest mockup with previously agreed upon modifications or changes.
 - e. The Architect in consultation with the testing service will determine at which step in the testing procedure retesting shall resume.
 - f. Incorporate agreed upon modifications into project submittals for record.

- g. If Cause of Failure was due to issues related to the quality of installation or failure to follow installation instructions or shop drawings, incorporate method to ensure future compliance into the fabrication and installation quality assurance and control programs.
- h. Retesting: Where manufacturing or installation methods require modification in order to meet specified performance requirements, the Contractor shall, at no additional cost to the Owner, modify, rebuild and retest mock-ups until the specified performance requirements are met. Show the required modifications on the project Shop Drawings and resubmit shop drawings as required.
 - 1) If the mockup fails to meet the specified requirements Contractor is required to pay the additional laboratory fees.
 - 2) Mock-up materials and assemblies, as tested and approved, govern the materials and assemblies furnished for field erection.
 - 3) At completion of testing, dismantle and dispose of mock-ups.
 - 4) All fees and expenses incurred by the Owner associated with the participation of the Architect, Owner, and Owner's designated technical representatives to observe both the repair/reconstruction of the mock-up, or re-testing of same, in whole or in part, shall be the sole responsibility of the Contractor.
- 8. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
- 9. Notify Architect **[seven]** <Insert number> days in advance of the dates and times when preconstruction laboratory mockups will be dismantled and disposed.
- H. Preconstruction Sealant Testing: Perform sealant manufacturer's standard tests for compatibility and adhesion of each material that will come in contact with sealants for each condition.
 - 1. Test a minimum five production-run samples each of metal, glazing, and other material.
 - 2. Prepare samples using techniques and primers required for installed assemblies.
 - 3. Perform tests under environmental conditions that duplicate those under which assemblies will be installed.
 - 4. For materials that fail tests, determine corrective measures necessary to prepare each material to ensure compatibility with and adhesion of sealants including, but not limited to, specially formulated primers. After performing these corrective measures on the minimum number of samples required for each material, retest materials.
 - 5. Preconstruction Terra Cotta Testing:
 - a. Execute a testing program to confirm material properties of custom terra cotta tiles and baguettes in the profiles, sizes, color, and finish specified for the project and ensure that acceptable material properties are maintained throughout production.
 - b. Testing shall be conducted by an independent certified testing laboratory. Test reports shall be submitted for approval by the Architect and shall indicate the laboratory name, address, date of testing, method of testing and the description and number of test specimens for each test.
 - c. Terra cotta testing shall be completed and test reports submitted prior to curtain wall performance mock-up testing.
 - d. The following material properties shall be identified for the terra cotta tile, tested in accordance with the requirements of ASTM C67-01, Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile.
 - 1) Modulus of Rupture (minimum 20 specimens)
 - 2) Compressive Strength (minimum 5 specimens)

- 3) Absorption: 24-hour Submersion and 5-hour Boiling Tests (separate sets of specimens, minimum 5 specimens each)
 - a) absorption by submersion not exceed 5% average, 6% individual specimen.
 - b) absorption by boiling not exceed 7% average, 8% individual specimen.
- 4) Freezing and Thawing (minimum 5 specimens, minimum 50 cycles each).
No specimen shall lose more than 0.5% of its original dry weight. No specimen shall crack, crumble, or fracture. Specimens shall conform to the approved color range samples before and after testing.
- 5) Efflorescence (minimum 10 specimens), specimens to be rated "non-efflorescence"
- 6) Weight per Unit Area (minimum 5 specimens)
- 7) Breaking Load (according to modified ASTM C67). Minimum 5 specimens. Supports shall be the actual hardware used for the project. Apply load at mid-span between supports. Report shall include breaking load, calculated section modules at mid-span, and calculated breaking stress.
- e. In accordance with ASTM C126-99 Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Unit, glazed tiles are for 3.1.8 Exterior Use. Properties of finish shall be in accordance with section 7 and tested per methods called out in section 16.
- f. Glazed tiles shall be tested in accordance with the requirements of ASTM C484, Standard Test Method for Thermal Shock Resistance of Glazed Ceramic Tile. Minimum 5 specimens. Specimens shall pass one cycle.

1.11 FIELD CONDITIONS

- A. Verify actual locations of structural supports for glazed curtain walls by field measurements before fabrication and indicate measurements on Shop Drawings.

1.12 WARRANTY

- A. Special Warranty: Installer agrees to repair or replace components of glazed aluminum curtain wall that do not comply with requirements or that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures including, but not limited to, excessive deflection.
 - b. Noise or vibration created by wind and thermal and structural movements.
 - c. Deterioration of metals[, metal finishes,] and other materials beyond normal weathering.
 - d. Water penetration through fixed glazing and framing areas.
 - e. Failure of operating components.
 2. Warranty Period: **[Two] [Five] [10] <Insert number>** years from date of Substantial Completion.
- B. Special Finish Warranty: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.
 1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Hunter units when tested in accordance with ASTM D 2244.

- b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D 4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
- 2. Warranty Period: **[Five] [10] [20] <Insert number>** years from date of Substantial Completion.
- C. Any other warranties of manufacturers for materials as set forth in Sections 079200 and 088000.
- D. Terra Cotta Warranty:
 - 1. Manufacturer shall warrant that terra cotta units shall not develop any defects which may affect the appearance of the product or may otherwise compromise the requirements of the system for a period of ten (10) years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design glazed curtain walls and connection to building structure including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
 - 1. Material properties indicated in this Section shall be considered as minimum properties.
- B. General Performance: Comply with performance requirements specified, as determined by testing of glazed curtain walls representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.
 - 1. Glazed aluminum curtain walls shall withstand all movements of supporting structure indicated on Drawings including, but not limited to, story drift, rotation, twist, column shortening, shrinkage, long-term creep, live loads, wind loads, deflection from uniformly distributed and concentrated live loads, cantilevered beam behavior (deflections in both upwards and downwards directions and resultant rotations), and loads , interim and otherwise, resulting from means and methods.
 - 2. Failure also includes the following:
 - a. Thermal stresses transferring to building structure.
 - b. Glass breakage.
 - c. Noise or vibration created by wind and thermal and structural movements.
 - d. Loosening or weakening of fasteners, attachments, and other components.
 - e. Failure of operating units.
- C. Structural Loads:
 - 1. Wind Loads: As indicated on Drawings.
 - 2. Snow and Ice Loads: **[As indicated on Drawings].**
 - 3. Other Design Loads: **[As indicated on Drawings] <Insert loads>.**
 - 4. Periodic Maintenance-Equipment Loads:
 - a. Minimum **<Insert loads> [250 pounds]** point load any place on mullions.
 - b. Equipment Specific Loads: **<Insert loads>.**
 - c. Facade Anchorage Loads as indicated in Section **<Insert Section Number and Title>.**
 - 5. Structural-Test Performance: Test according to ASTM E 330 as follows:

- a. When tested at positive and negative wind-load design pressures, assemblies do not evidence deflection exceeding specified limits.
 - b. When tested at 150 percent of positive and negative wind-load design pressures, assemblies, including anchorage, do not evidence material failures, structural distress, and permanent deformation of main framing members exceeding 0.2 percent of span.
 - c. Test Durations: As required by design wind velocity, but not less than 10 seconds.
6. Deflection:
- a. Deflection Normal to Wall Plane: Limited to **[edge of glass in a direction perpendicular to glass plane not exceeding 1/175 of the glass edge length for each individual glazing lite] [1/175 of clear span for spans up to 13 feet 6 inches (4.1 m) and to 1/240 of clear span plus 1/4 inch (6.35 mm) for spans greater than 13 feet 6 inches (4.1 m)] <Insert deflection limit>** or an amount that restricts edge deflection of individual glazing lites to 3/4 inch (19.1 mm), whichever is less.
 - b. Deflection Parallel to Glazing Plane: Limited to **[1/360 of clear span or 1/8 inch (3.2 mm), whichever is smaller] [amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than 1/8 inch (3.2 mm)]**.
 - c. Operable Units: Provide a minimum 1/16-inch (1.6-mm) clearance between framing members and operable units.
 - d. Cantilever Deflection: Where framing members overhang an anchor point, as follows:
 - 1) Perpendicular to Plane of Wall: No greater than 1/240 of clear span plus 1/4-inch (6.35-mm) for spans greater than 11 feet 8-1/4 inches (3.6 m) or 1/175 times span, for spans less than 11 feet 8-1/4 inches (3.6 m).
 - e. Twisting (rotation) of horizontal members due to the weight of the glass should not exceed 1° measured between ends and center of each span.
 - f. Deflection due to dead load at sloped glazing and canopies: Limit to L/500.
 - g. Design to resist each of the load combinations indicated in ASCE/SEI 7 and limit deflection of sloped glazing and canopies to L/240 or 3/4 inch, whichever is less.
 - h. Deflection of horizontal Fins due to dead load: Limit to L/240.
 - i. Deflection of horizontal Fins due to worst case of snow or ice load: Limit to L/240.
 - j. Stresses resulting from thermal expansion/contraction, shall not cause permanent deformation of Fin assemblies or disengagement from the glazed system.
 - k. Exposed Metal Panels and Shadow Box Panel:
 - 1) Center of Panel Deflection of vertical metal panels between supports or stiffeners not to exceed L/120.
 - l. Deflection of vertical fins:
 - 1) Along the fin between anchor points: L/360, L=distance between anchor points.
 - 2) Pivot relative to anchor point: L/120, L=depth of the fin.
 - m. PV FIN Loads: Refer to Specification Section **<Insert Section Number and Title>**
 - n. Guard Rail Structural Performance: Where the curtain wall system, and its attachment to structure, functions as a Guard Railing, it shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:
 - 1) Top Rails of Guards:

- a) Uniform load of 50 lbf/ft. (0.73 kN/m) applied in any direction.
 - b) Concentrated load of 200 lbf (0.89 kN) applied in any direction.
 - c) Uniform and concentrated loads need not be assumed to act concurrently.
- 7. Interstory Drift: Accommodate design displacement of adjacent stories indicated.
 - a. Design Displacement: **[As indicated on Drawings] <Insert design displacement>**.
 - b. Test Performance: Complying with criteria for passing based on building occupancy type when tested in accordance with AAMA 501.4 at elastic **[and inelastic]** design displacement.
- 8. Seismic Performance: Glazed curtain walls shall withstand the effects of earthquake motions determined in accordance with **[ASCE/SEI 7] <Insert requirement>**.
 - a. Component Importance Factor as indicated on drawings.
 - b. Seismic Drift Causing Glass Fallout: Complying with criteria for passing based on building occupancy type when tested in accordance with AAMA 501.6.
- 9. Vertical Interstory Movement: Complying with criteria for passing based on building occupancy type when tested in accordance with AAMA 501.7 at design displacement.
- 10. Air Infiltration: Test in accordance with ASTM E 283 for infiltration as follows:
 - a. Fixed Framing and Glass Area:
 - 1) Maximum air leakage of **[0.06 cfm/sq. ft. (0.30 L/s per sq. m)] <Insert value>** at a static-air-pressure differential of **[6.24 lbf/sq. ft. (300 Pa)] <Insert value>**.
- D. Water Penetration under Static Pressure: Test in accordance with ASTM E 331 as follows:
 - 1. No evidence of water penetration through fixed glazing and framing areas when tested in accordance with a minimum static-air-pressure differential of **[6.24 lbf/sq. ft. (300 Pa)] [10 lbf/sq. ft. (480 Pa)] [15 lbf/sq. ft. (720 Pa)] <Insert value>**.
- E. Water Penetration under Dynamic Pressure: Test in accordance with AAMA 501.1 as follows:
 - 1. No evidence of water penetration through fixed glazing and framing areas when tested at dynamic pressure equal to **[6.24 lbf/sq. ft. (300 Pa)] [10 lbf/sq. ft. (480 Pa)] [15 lbf/sq. ft. (720 Pa)] <Insert value>**.
- F. Energy Performance: Certify and label energy performance in accordance with NFRC as follows:
 - 1. Thermal Transmittance (U-factor):
 - a. Fixed vision glazing and framing areas:
 - 1) Total product U-factor of not more than **<Insert Value>** Btu/sq. ft. x h x deg F as determined according to NFRC 100.
 - b. Fixed Opaque glazing and framing areas:
 - 1) Total product U-factor of not more than **<Insert Value>** Btu/sq. ft. x h x deg F as determined according to NFRC 100.
- G. Condensation Resistance:
 - 1. Design the wall and its components to not develop any visible interior condensation on or within any part of the fenestration system that is inboard of the manufacturer's defined airtightness plane of the curtain wall assembly framing members or glazing under the following conditions:
 - a. Exterior air dry bulb temperature: **<insert value>** degrees F.
 - b. Interior air dry bulb temperature: **<insert value>** degrees F.
 - c. Interior Relative Humidity: **<insert value>** % RH.

2. Fixed glazing and framing areas shall have an NFRC-certified condensation resistance rating of no less than **[15] [25] [35] [45] <Insert value>** as determined in accordance with NFRC 500.
- H. Self Generated Noise:
1. Design and install glazing systems and component parts to minimize noise caused by movement of the system. The system shall not generate noise due to creaking, drumming, or rattle.
 2. Metal to metal contact between inter-locking members is not permitted unless specifically indicated on the structural drawings.
- I. Noise Reduction: Test in accordance with ASTM E 90, with ratings determined by ASTM E 1332, as follows.
1. Outdoor-Indoor Transmission Class: Minimum **[26] [30] [34] <Insert number>**.
- J. Blast Resistance:
1. Hazard Rating: **[No Break] [No Hazard] [Minimal Hazard] [Very Low Hazard] [Low Hazard] [High Hazard]** per ASTM F 1642.
 2. Performance Condition: **[1] [2] [3a] [3b] [4] [5]** per GSA-TS01.
- K. Windborne-Debris Impact Resistance: Pass missile-impact and cyclic-pressure tests when tested in accordance with ASTM E 1886 and testing information in ASTM E 1996 for **[Wind Zone 1] [Wind Zone 2] [Wind Zone 3] [Wind Zone 4]**.
1. Large-Missile Test: For glazed openings located within 30 feet (9.1 m) of grade.
 2. Small-Missile Test: For glazed openings located more than 30 feet (9.1 m) above grade.
- L. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes:
1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 2. Test Interior Ambient-Air Temperature: 72 deg F
 3. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested in accordance with AAMA 501.5.
 - a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of **[180 deg F (82 deg C)] <Insert temperature>**.
 - b. Low Exterior Ambient-Air Temperature: **[0 deg F (minus 18 deg C)] <Insert temperature>**.
- M. Structural-Sealant Joints:
1. Designed to produce tensile or shear stress of less than 20 psi (138 kPa).
 2. A glass or panel unit shall not be attached by structural silicone on both sides of a frame expansion joint.
- N. Structural Sealant: Capable of withstanding tensile and shear stresses imposed by structural-sealant-glazed curtain walls without failing adhesively or cohesively. When tested for preconstruction adhesion and compatibility, cohesive failure of sealant shall occur before adhesive failure.
1. Adhesive failure occurs when sealant pulls away from substrate cleanly, leaving no sealant material behind.

2. Cohesive failure occurs when sealant breaks or tears within itself but does not separate from each substrate because sealant-to-substrate bond strength exceeds sealant's internal strength.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. Arcadia, Inc.
 2. EFCO Corporation.
 3. Kawneer North America; an Arconic company.
 4. Oldcastle BuildingEnvelope.
 5. Pittco Architectural Metals, Inc.
 6. Schuco USA
 7. TGP.
 8. Tubelite Inc.
 9. Wausau Window and Wall Systems.
 10. YKK AP America Inc.
 11. <Insert Manufacturer>.
- B. Source Limitations: Obtain all components of curtain-wall system, including framing [venting windows] [entrances] [sun control] and accessories, from single manufacturer.

2.3 FRAMING

- A. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
 1. Fabrication Method: Factory-fabricated system.
 2. Construction: Thermally broken.
- B. Thermally Broken Construction:
 1. Provide one of the following types of thermal break construction for use in separating aluminum components from the interior to the exterior:
 - a. Insulbar: A glass-reinforced polyamide 6/6 nylon, with glass fibers oriented in three directions, mechanically crimped into dual dovetail-shaped slots in the aluminum extrusions.
 - b. Azon or similar construction as approved: A poured and debridged polyurethane construction with mechanically abraded surfaces that lock in the polyurethane minimizing dry shrinkage and fracturing of the polyurethane.
 - c. Pressure Bar: A continuous extruded aluminum member anchored to the window framing system with mechanical fasteners and separated from the framing by an insulating non-metallic spacer.
- C. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.
 1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.

- D. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials or Dead-soft, 0.018-inch- (0.457-mm-) thick stainless steel, ASTM A 240/A 240M of type recommended by manufacturer.
- E. Framing Sealants: Manufacturer's standard sealants with VOC content of 250g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA method 24).

2.4 MATERIALS

- A. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
 - 1. Sheet and Plate: ASTM B 209 (ASTM B 209M).
 - 2. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).
 - 3. Extruded Structural Pipe and Tubes: ASTM B 429.
 - 4. Structural Profiles: ASTM B 308/B 308M.
 - 5. Welding Rods and Bare Electrodes: AWS A5.10/A5.10M.
- B. Steel Reinforcement:
 - 1. Structural Shapes, Plates, and Bars: ASTM A 36/A 36M.
 - 2. Cold-Rolled Sheet and Strip: ASTM A 1008/A 1008M.
 - 3. Hot-Rolled Sheet and Strip: ASTM A 1011/A 1011M.
- C. Steel Reinforcement Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods in accordance with recommendations in SSPC-SP COM, and prepare surfaces in accordance with applicable SSPC standard.
- D. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] <Insert value> percent.
- E. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] [50] <Insert value> percent.
- F. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- G. Indigenous Materials: Products shall be manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.
- H. Regional Materials: Products shall be manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site. If materials are transported by rail or water, the distance transported by rail or water shall be multiplied by 0.25 to determine the distance to Project site.

2.5 VENTING WINDOWS

- A. Aluminum Windows: As specified in Section 08 5113 "Aluminum Windows."
- B. Aluminum Windows: Manufacturer's standard units, complying with AAMA/WDMA/CSA 101/I.S.2/A440, with self-flashing mounting fins, and as follows:
1. Window Type: **[Horizontal sliding] [Awning] [Single hung] [As indicated on Drawings] <Insert type>**.
 2. Minimum Performance Class: **[CW] [AW] <Insert class>**.
 3. Minimum Performance Grade: **[30] [35] [40] [45] [50] [As indicated on Drawings] <Insert number>**.
 4. Aluminum Extrusions: ASTM B 221/ASTM B 221M, alloy and temper recommended by manufacturer for strength, corrosion resistance, and application of required finish, but not less than 0.064-inch (1.63-mm) thickness at any location for main frame and sash members.
 5. Mullions: Between adjacent windows, fabricated of extruded aluminum matching finish of window units.
 6. Fasteners, Anchors, and Clips: Nonmagnetic stainless steel, aluminum, or other noncorrosive material, compatible with aluminum window members, trim, hardware, anchors, and other components of window units. Fasteners shall not be exposed, except for attaching hardware.
 - a. Reinforcement: Where fasteners screw-anchor into aluminum less than 0.128 inch (3.26 mm) thick, reinforce interior with aluminum or nonmagnetic stainless steel to receive screw threads, or provide standard, noncorrosive, pressed-in, spline grommet nuts.
 7. Hardware: Manufacturer's standard; of aluminum, stainless steel, die-cast steel, malleable iron, or bronze; including the following:
 - a. Cam-action sweep sash lock and keeper at meeting rails.
 - b. Spring-loaded, snap-type lock at jambs.
 - c. Pole-operated, cam-action locking device on meeting rail where rail is more than 72 inches (1830 mm) above floor.
 - d. Lift handles for single-hung units.
 - e. Nylon sash rollers for horizontal-sliding units.
 - f. Steel or bronze operating arms.
 8. Sliding-Type Weather Stripping: Woven-pile weather stripping of wool, polypropylene, or nylon pile and resin-impregnated backing fabric; complying with AAMA 701/702.
 9. Insect Screens: Provide removable insect screen on each operable exterior sash, with screen frame finished to match window unit, complying with SMA 1004 or SMA 1201, and as follows:
 - a. Aluminum Wire Fabric: 18-by-18 (1.1-by-1.1-mm), 18-by-16 (1.1-by-1.3-mm), or 18-by-14 (1.1-by-1.5-mm) mesh of 0.013-inch- (0.3-mm-) diameter, coated aluminum wire.
 - b. Glass-Fiber Mesh Fabric: 18-by-16 (1.1-by-1.3-mm) or 18-by-14 (1.1-by-1.5-mm) mesh of PVC-coated, glass-fiber threads, woven and fused to form a fabric mesh; complying with ASTM D 3656.
 - c. Fabric: Manufacturer's standard aluminum wire fabric or glass-fiber mesh fabric.
 10. Glazing: **[Same as adjacent glazed curtain-wall glazing] <Insert glazing>**.
 11. Finish: **[Match adjacent glazed curtain-wall finish] <Insert finish>**.

2.6 ENTRANCES

- A. Entrances: Comply with [Section 08 4113 "Aluminum-Framed Entrances and Storefronts."] <Insert Section.>

2.7 SUN CONTROL

- A. Sunshades: Assemblies consisting of manufacturer's standard outrigger brackets, louvers, and fascia, designed for attachment to curtain wall with mechanical fasteners.
1. Orientation: [Horizontal] [Vertical].
 2. Projection from Wall: [As indicated on Drawings] [20 inches (508 mm)] [25 inches (635 mm)] [30 inches (762 mm)] [35 inches (889 mm)] <Insert projection>.
 3. Outriggers: [Straight with square edges] [Straight with rounded edge] [Curved] [Wedge] <Insert shape>.
 4. Louvers:
 - a. Number: [Three] [Four] [Five] <Insert number> louvers per unit.
 - b. Shape: [Planar] [Arched] [Circular] [Airfoil] [Square].
 - c. Width: [6 inches (152 mm)] [8 inches (203 mm)] [10 inches (254 mm)] <Insert dimension>.
 - d. Mounting Angle: [25] [30] [35] <Insert number> degrees.
 5. Fascia: [Rectangular] [Bullnose] [Angular] [Circular].
 6. Finish: [Match adjacent glazed curtain wall] <Insert finish>.
- B. Light Shelves: Light-reflecting assemblies consisting of manufacturer's standard support brackets or channels, and aluminum tray, designed for attachment to interior of curtain wall with mechanical fasteners.
1. Projection from Wall: [As indicated on Drawings] [20 inches (508 mm)] [25 inches (635 mm)] [30 inches (762 mm)] [35 inches (889 mm)] <Insert projection>.
 2. Finish: [glazed curtain wall] <Insert finish>.
- C. Materials:
1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
 - a. Sheet and Plate: ASTM B 209/ASTM B 209M.
 - b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221/ASTM B 221M.
 - c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429.
 - d. Structural Profiles: ASTM B 308/B 308M.

2.8 GLAZING

- A. Glazing: Comply with Section 08 8000 "Glazing."
- B. Structural Glazing Sealants: ASTM C 1184, chemically curing silicone formulation that is compatible with system components with which it comes in contact, specifically formulated and tested for use as structural sealant and approved by structural-sealant manufacturer for use in curtain-wall assembly indicated.
1. Color: Black.

- C. Weatherseal Sealants: ASTM C 920 for Type S; Grade NS; Class 25 (minimum); Uses NT, G, A, and O; chemically curing silicone formulation that is compatible with structural sealant and other system components with which it comes in contact; recommended by structural-sealant, weatherseal-sealant, and structural-sealant-glazed curtain-wall manufacturers for this use.
 - 1. Color: Black.
- D. Glazing Gaskets: **[Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.] [Comply with Section 08 8000 "Glazing."]**
 - 1. Provide gaskets that are compatible with glazing sealants and will provide for silicone adhesion.
- E. Glazing Sealants: Comply with Section 08 8000 "Glazing."
 - 1. Sealant shall have a VOC content of 250 g/L or less.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 3. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 4. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 5. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.9 EXTERIOR ALUMINUM FINIS

- A. Exterior Aluminum Fins: Assemblies consisting of manufacturer's standard outrigger brackets and custom profile fins designed for attachment to curtain wall with mechanical fasteners.
 - 1. Orientation: Vertical.
 - 2. Projection from Wall: As indicated on Drawings.
 - 3. Outriggers: Straight with square edges.
 - 4. Fins:
 - a. Shape: As indicated on Drawings.
 - b. Width: As indicated on Drawings.
- B. Materials:
 - 1. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
 - a. Sheet and Plate: ASTM B 209 (ASTM B 209M).
 - b. Extruded Bars, Rods, Profiles, and Tubes: ASTM B 221 (ASTM B 221M).

- c. Extruded Structural Pipe and Tubes: ASTM B 429/B 429.
- 2. Structural Profiles: ASTM B 308/B 308M.

C. Supports and Fixings

- 1. Each Fin shall be supported and reinforced within frame of a single curtain wall unit with mechanical connections securely attached to the back-up framing structure.
- 2. All support clips and framing members shall be aluminum and shall conform to requirements for aluminum specified herein.
- 3. The width of joints between installed Fins shall be consistent and as shown on the Drawings.
- 4. Clips and support framing shall be concealed unless indicated otherwise on the Drawings.
- 5. The support system shall be designed and installed such that the replacement of individual damaged Fins is possible using simple methods and without disturbing adjacent Fins.
- 6. Provide 1/4-inch minimum edge clearance between the edge of IGU and support bracket.

2.10 TERRA COTTA

A. General:

- 1. Provide custom extruded hollow terra cotta clay baguettes with the profiles and dimensions indicated on the Drawings.
- 2. Thickness shall be as required to meet the design and performance requirements.
- 3. Custom through-body color clay with a fired finish for all surfaces exposed to view to match finish approved on the aesthetic mockup.
- 4. Terra cotta baguettes shall be flat with no noticeable warpage, buckling, or other surface irregularities, and within the following tolerances.
 - a. width of baguettes: +/- 1/16 inch
 - b. depth of baguettes: +/- 1/16 inch for 4" depth, +/- 3/32 inch for 8" depth, +/- 1/8 inch for 12" depth
 - c. height of baguettes: +/- 1/16 inch
 - d. thickness of baguettes: +/- 1/16 inch
 - e. flatness across exposed face: +/- 0.25% of length in direction of measurement

B. Supports and Fixings

- 1. Each terra cotta baguette shall be supported and reinforced within frame of a single curtain wall unit with mechanical connections securely attached to the back-up framing structure.
- 2. All support clips and framing members shall be aluminum or stainless steel, shall be approved for use by the manufacturer of the terra cotta, and shall conform to requirements for aluminum and/or stainless steel specified herein.
- 3. Support clips and framing shall incorporate continuous neoprene gaskets and setting pads to prevent terra cotta baguettes from contacting metal components and to prevent from rattling in the wind.
- 4. The width of joints between installed terra cotta baguettes shall be consistent and as shown on the Drawings.
- 5. Clips and support framing shall be concealed unless indicated otherwise on the Drawings.
- 6. The support system shall be designed and installed such that the replacement of individual damaged baguettes is possible using simple methods and without disturbing adjacent baguettes.
- 7. Provide ¼ inch minimum edge clearance between the edge of IGU and support bracket.

- C. The following are approved terra cotta manufacturers: Alternate fabricators are subject to approval:
1. Boston Valley Terra cotta
 2. Shildan USA, Inc.
 3. NBK North America
 4. **<Insert Manufacturer>**

2.11 ACCESSORIES

- A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
 2. Reinforce members as required to receive fastener threads.
 3. No exposed fastenings will be permitted in aluminum work, unless otherwise specified or indicated.
 4. In certain locations where it is impossible or highly impractical, or in locations where exposed but hidden from view, consideration will be given to exposed fastenings where such fastenings are Phillips, flat head, or countersunk machine screws[, **finished to match framing system**][, **fabricated from 300 series stainless steel**].
- B. Anchors: Three-way adjustable anchors with minimum adjustment of **[1 inch (25.4 mm)]** **<Insert dimension>** that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.
1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A 123/A 123M or ASTM A 153/A 153M requirements.
- C. Concealed Flashing: **[Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials] [or] [Dead-soft, 0.018-inch-(0.457-mm-) thick stainless steel, ASTM A 240/A 240M of type recommended by manufacturer]**.
- D. Bituminous Paint: Cold-applied asphalt-mastic paint complying with SSPC-Paint 12 requirements except containing no asbestos, formulated for 30-mil (0.762-mm) thickness per coat.
- E. Slide Bearings (At slip-joints in exterior wall): Wherever materials are subject by engineering design to movement, provide suitable low friction material(s) such as:
1. Polytetrafluoroethylene fluoropolymer: ASTM D4894, Teflon as manufactured by Dupont or equal.
 2. Acetal homopolymer: ASTM D6100, Delrin as manufactured by Dupont or equal.
 3. Nylon: ASTM D4066.
 4. Low-friction materials shall be dimensionally-stable, impact-resistant and impervious to moisture.
 5. Mating surfaces: PTFE/AHP and PTFE/AHP or PTFE/AHP and mirror finish stainless steel.
- F. Bond Breaker Tape: Lithographer tape as manufactured by the 3M Company.

- G. Weep Hole Baffle: PVC-coated, reticulated open-cell urethane foam, 45 pores per 1 linear inch; filter to be installed compressed to 50 percent of original width.
- H. Self-adhering Stainless Steel Flexible Flashing:
1. Basis of Design: York Manufacturing, Inc.; York [304SA] [316SA]
 2. Characteristics:
 - a. Type: stainless steel core with one stainless steel face (outward facing) with a butyl block co-polymer adhesive (inward facing).
 - b. Stainless steel: type 304 or 316, ASTM A240. Domestically sourced per DFARS 252.225-7008 and/or DFARS 252.225-7009.
- I. Preformed Silicone-Sealant Extrusion: Manufacturer's standard system consisting of translucent cured low-modulus silicone extrusion with preformed inside and outside corners, sized to fit opening widths, with a single-component, neutral-curing, Class 100/50 (low-modulus) silicone sealant for bonding extrusions to substrates.
1. Dow Corning Corporation; Silicone Transition Strip System.
 2. Momentive Performance Materials Inc.; UST2200 UltraSpan.
 3. Prosoco; SureSpan EX
 4. Tremco; Proglaze ETA
- J. Spandrel Insulation
1. Provide one of the following:
 - a. Un-Faced Thermafiber FireSpan 90.
 - b. Un-Faced Rockwool Curtainrock 80
 2. Thickness: **[Insert Thickness]** minimum or as required to meet the total product thermal performance and fire rated joint requirements.
 3. Provide one of the following:
 - a. Foil-Faced Thermafiber FireSpan 90.
 - b. Foil-Faced Rockwool Curtainrock 80
 4. Thickness: **[Insert Thickness]** minimum or as required to meet the total product thermal performance and fire rated joint requirements.
- K. Shadow Box Panel: For use on the exterior side of the spandrel insulation.
1. 1/8 inch minimum aluminum plate
 2. Provide concealed stiffeners and attachment clips as required to provide a flat surface free of distortion, buckling, and oil-canning to and meet performance requirements.
 3. Provide extruded aluminum stiffeners or alternate panel stiffening devices designed to prevent "telegraphing" or "read through" of the stiffening device on the exposed face of the panel.
 4. Color: **[Insert Color]**.
 5. Shop Coated post-fabrication.
 6. Comply with 074213.16 "Formed Metal Wall Panels" for requirements not listed in this section.
- L. Interior Aluminum Panel: For use on the interior side of opaque curtain wall areas exposed to view.
1. 1/8 inch thick minimum aluminum plate.
 2. Interior Location Color: **[Insert Color]**.
 3. Shop Coated post-fabrication.

4. Provide concealed stiffeners and attachment clips as required to provide a flat surface free of distortion, buckling, and oil-canning.
 5. **[Form perimeters by route and return.]**
 6. Provide concealed splice plates, finished to match.
 7. Provide extruded aluminum stiffeners or alternate panel stiffening devices designed to prevent “telegraphing” or “read through” of the stiffening device on the exposed face of the panel.
 8. Comply with 074213.16 "Formed Metal Wall Panels" for requirements not listed in this section.
- M. Exterior Aluminum Spandrel Panel: For use on the exterior side of opaque curtain wall areas.
1. 1/8 inch thick minimum aluminum plate.
 2. Exterior Location Color: **[Insert Color]**.
 3. Shop Coated post-fabrication.
 4. Provide concealed stiffeners and attachment clips as required to provide a flat surface free of distortion, buckling, and oil-canning.
 5. **[Form perimeters by route and return.]**
 6. Provide extruded aluminum stiffeners or alternate panel stiffening devices designed to prevent “telegraphing” or “read through” of the stiffening device on the exposed face of the panel.
 7. Comply with 074213.16 "Formed Metal Wall Panels" for requirements not listed in this section.
- N. Interior Aluminum Backpan: For use on the interior side of opaque curtain wall areas exposed to view.
1. 1/8 inch thick minimum aluminum plate.
 2. Interior Location Color: **[Insert Color]**.
 3. Shop Coated post-fabrication.
 4. Provide concealed stiffeners and attachment clips as required to provide a flat surface free of distortion, buckling, and oil-canning.
 5. **[Form perimeters by route and return.]**
 6. Provide concealed splice plates, finished to match.
 7. Provide extruded aluminum stiffeners or alternate panel stiffening devices designed to prevent “telegraphing” or “read through” of the stiffening device on the exposed face of the panel.
 8. Comply with 074213.16 "Formed Metal Wall Panels" for requirements not listed in this section.
- O. Galvanized Metal Backpan: For use at the interior side of the spandrel insulation in concealed locations. 22GA minimum galvanized steel or as required to meet the performance requirements indicated.
- P. Provide aluminum end closures at all horizontal and vertical caps and projections with provisions for drainage.
- Q. Aluminum Trim and Closure Panels: Formed and Extruded aluminum profiles of thickness required and reinforced as required to support imposed loads.
1. Profile: as indicated on drawings.
 2. Fully weld end caps to provided surface for sealant joint installation and a watertight installation.

3. Provide concealed extruded aluminum splice plates, with concealed bed seals on all surfaces.
4. Finish to match curtain wall.

2.12 FABRICATION

- A. Form or extrude aluminum shapes before finishing.
- B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- C. Factory fabricate all curtain wall components. Field fabrication is not acceptable.
- D. Fabricate components that, when assembled, have the following characteristics:
 1. Profiles that are sharp, straight, and free of defects or deformations.
 2. Accurately fitted joints with ends coped or mitered.
 3. Physical and thermal isolation of glazing from framing members.
 4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
 5. Provisions for field replacement of glazing from **[exterior] [interior] [interior for vision glass and exterior for spandrel glazing or metal panels]**.
 6. Provisions for safety railings mounted **[on interior face of mullions] [between mullions at interior]**.
 7. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
 8. Components curved to indicated radii. Provide framing members that have adequate surface to accommodate two lines of air and water sealant joints between curtain walls and adjacent construction.
 9. Primary seal shall be both an air and water seal.
 - a. Secondary seal shall be water seal.
 - b. Provide watertight caps at perimeter framing members to accommodate sealant joints between curtain walls and adjacent construction.
 10. Touch-up all aluminum cut edges that will be exposed to view with color similar to curtain wall finish.
 11. Provide closed back mullions at perimeter conditions.
 12. Provide mullions with closed tongue back wall profile.
- E. Factory-Assembled Frame Units:
 1. Rigidly secure nonmovement joints.
 2. Prepare surfaces that are in contact with structural sealant in accordance with sealant manufacturer's written instructions, to ensure compatibility and adhesion.
 3. Preparation includes, but is not limited to, cleaning and priming surfaces.
 4. Seal joints watertight unless otherwise indicated.
 5. Install glazing to comply with requirements in Section 08 8000 "Glazing."
- F. Fabricate components that, when assembled, have the following characteristics:
 1. Internal guttering system or other means to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.

2. Pressure-equalized system or double barrier design with primary air and vapor barrier at interior side of glazed aluminum curtain wall and secondary seal weeped and vented to exterior.
3. After fabrication, clearly mark components to identify their locations in Project in accordance with Shop Drawings.

2.13 ALUMINUM FINISHES

- A. Where aluminum surfaces are concealed and are a substrate for liquid applied sealants, provide a Class 1A chemical conversion coating complying with Mil-C-5541.
- B. Clear Anodic Finish: AAMA 611, **[AA-M12C22A41, Class I, 0.018 mm] [AA-M12C22A31, Class II, 0.010 mm]** or thicker.
- C. Color Anodic Finish: AAMA 611, **[AA-M12C22A42/A44, Class I, 0.018 mm] [AA-M12C22A44, Class I, 0.018 mm] [AA-M12C22A32/A34, Class II, 0.010 mm]** or thicker.
 1. Color: **[Light bronze] [Medium bronze] [Dark bronze] [Champagne] [Black] <Insert color>**.
- D. Color: **[Match Architect's sample] [As selected by Architect from full range of industry colors and color densities]**.
- E. Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of 1.5 mils (0.04 mm). Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 1. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>**.
- F. Thermosetting Acrylic Enamel: Factory applied finish for exposed interior aluminum surfaces in accordance with AAMA 2603, equivalent to PPG Industries, Inc. "Duracron" or "Polycron III", with a dry film thickness of 0.025 mm (1.0 mil).
 1. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>**.
- G. High-Performance Organic Finish, Two-Coat PVDF: Fluoropolymer finish complying with AAMA 2604 and containing not less than 50 percent PVDF resin by weight in color coat.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions **[for seacoast and severe environments]**.
 2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>**.
- H. Superior-Performance Organic Finish, Two-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in color coat.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions **[for seacoast and severe environments]**.

2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.**
- I. Superior-Performance Organic Finish, Three-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions **[for seacoast and severe environments]**.
 2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.**
 - J. Superior-Performance Organic Finish, Four-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in both color coat and clear topcoat.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions **[for seacoast and severe environments]**.
 2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.**
 - K. Superior-Performance Organic Finish, Single-Coat FEVE: Fluoropolymer finish complying with AAMA 2605.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
 2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.**
 - L. Superior-Performance Organic Finish, Two-Coat FEVE: Fluoropolymer finish complying with AAMA 2605.
 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions for seacoast and severe environments.
 2. Color and Gloss: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range] <Insert color and gloss>.**
- 2.14 SOURCE QUALITY CONTROL
- A. Structural Sealant: Perform quality-control procedures complying with ASTM C 1401 recommendations including, but not limited to, assembly material qualification procedures, sealant testing, and assembly fabrication reviews and checks.
 - B. Manufacturer performed periodic Shop Wind, Air, and Water Testing
 1. Wind Load Test per ASTM C1401 at design pressure.
 2. Air infiltration when tested according to ASTM E 283 at the specified pressure.
 3. Water penetration under the specified static pressure when tested according to ASTM E 331.
 4. Test Frequency (per unitized curtain wall type)
 - a. Test one (1) unit prior to completion of the first 25 units.

- b. Test one (1) unit for every 150 completed units thereafter.
- 5.

PART 3 - EXECUTION

3.1 MOCKUP APPROVAL

- A. Do not proceed with fabrication or erection of curtain wall work before completion and approval of mockups.

3.2 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 PREPARATION

- A. Prepare surfaces that are in contact with sealant in accordance with sealant manufacturer's written instructions to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.

3.4 INSTALLATION

- A. General:
 - 1. Comply with manufacturer's written instructions.
 - 2. Do not install damaged components.
 - 3. Fit joints to produce hairline joints free of burrs and distortion.
 - 4. Rigidly secure nonmovement joints.
 - 5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
 - 6. Where welding is required, weld components in concealed locations to minimize distortion or discoloration of finish. Protect glazing surfaces from welding. Perform field welding under the same requirements as for shop welding.
 - 7. Thoroughly clean welds and adjacent burned areas on primed surfaces and paint the areas with priming paint of type used for shop coats, or zinc rich paint for galvanized steel.
 - 8. Seal joints watertight unless otherwise indicated.
- B. Anchors and Connections
 - 1. Connections between different materials shall be designed to allow for the differential thermal movement of the respected materials.
 - 2. Anchors and connections that are designed for movement shall be of such construction that friction is low enough to allow for such movement without buckling and other damage and without causing binding and noises.
 - 3. Metal surfaces shall be separated in such a manner that metal does not move on metal. Materials used for this purpose shall be low friction components, sealants or gaskets as applicable.
 - 4. Anchorages to Structural Steel shall not induce rotational forces in supporting members if not designed for these forces.

5. All component parts to be installed for noiseless movement caused by thermal expansion, and when subject to dynamic load caused by external wind pressure
 6. Avoid excess shimming that may induce additional stress on fasteners. The total thickness (t) of a shim pack shall not exceed a dimension equal to the diameter (d) of the fastener/anchor. Where $t > d$, the fastener/anchor shall be recalculated to take into account the additional stress from bending on the fastener with the assumption that the shim does not contribute to resistance to fastener bending.
 7. Shim packs that resist compressive forces only may be high-impact plastic. Shim packs subject to shear forces shall be stainless steel plates pinned together to form a monolithic shim.
- C. Metal Protection:
1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with primer, applying sealant or tape, or installing nonconductive spacers as recommended by manufacturer for this purpose.
 2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
- D. Install components plumb and true in alignment with established lines and grades.
- E. Install operable units level and plumb, securely anchored, and without distortion. Adjust weather-stripping contact and hardware movement to produce proper operation.
- F. Install glazing as specified in Section 08 8000 "Glazing."
1. Prepare surfaces that are in contact with structural sealant in accordance with sealant manufacturer's written instructions, to ensure compatibility and adhesion. Preparation includes, but is not limited to, cleaning and priming surfaces.
- G. Install weatherseal sealant in accordance with Section 07 9200 "Joint Sealants" and in accordance with sealant manufacturer's written instructions, to produce weatherproof joints. Install joint filler behind sealant as recommended by sealant manufacturer.
- H. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within glazed aluminum curtain wall to exterior.
- I. Shadow Box Panel:
1. Install aluminum shadow box panel with concealed clips and fasteners.
 2. Seal fasteners in shadow box area.
 3. Provide accommodation for curtain movement.
 4. Provide accommodation to prevent noise due to panel movement.
 5. Weep and vent shadow box area to the exterior as required by glazing manufacturer.
 6. Seal shadow box panel to curtain wall frame.
 7. Provide weeps through bottom sealant.
 8. Seal interfaces of vertical and horizontal framing members full depth of mullion at shadow box and spandrel areas.
 9. Provide a means for long term securement of panel that prevents future dislodging or displacement.
- J. **[Aluminum] [or] [Galvanized Metal] Backpan:**
1. Install backpan in a manner to provide an air and vapor tight seal to the curtain wall framing and per manufacturer's installation instructions.

2. Apply a bead of sealant (min 3/8") to inside corner of backpan flange.
3. Apply sealant onto curtain wall mullion. Insert backpan into opening, maintaining equal space all around.
4. Fasten at 18 inches on center minimum or as required to meet performance requirement.
5. Seal over all screw heads and apply fillet bead of sealant between edge of backpan and curtain wall framing.
6. Apply fillet bead of sealant at the interface of vertical and horizontal mullions within the spandrel area. Connect seal to perimeter seal between backpan and framing.
7. Seal penetrations through backpans in an air and watertight manner.
8. Where required at curtain anchors, provide accommodation for movement.
9. Where required at curtain wall expansion joints, provide accommodation for movement in the backpan.

K. Spandrel Insulation: Install board insulation in curtain-wall construction where indicated on Drawings according to curtain-wall manufacturer's written instructions and as required to meet perimeter fire stopping requirements.

1. Hold insulation in place by securing metal clips and straps or integral pockets within curtain wall frames, spaced at intervals recommended in writing by insulation manufacturer to hold insulation securely in place without touching spandrel glass. Maintain cavity width of dimension indicated between insulation and glass.

L. Install insulation where it contacts perimeter fire-containment system to prevent insulation from bowing under pressure from perimeter fire-containment system.

3.5 ERECTION TOLERANCES

A. Erection Tolerances: Install glazed curtain walls to comply with the following maximum tolerances:

1. Plumb: 1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6 mm in 12 m).
2. Level: 1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6 mm in 12 m).
3. Alignment:
 - a. Where surfaces abut in line or are separated by reveal or protruding element up to 1/2 inch (12.7 mm) wide, limit offset from true alignment to 1/16 inch (1.6 mm).
 - b. Where surfaces are separated by reveal or protruding element from 1/2 to 1 inch (12.7 to 25.4 mm) wide, limit offset from true alignment to 1/8 inch (3.2 mm).
 - c. Where surfaces are separated by reveal or protruding element of 1 inch (25.4 mm) wide or more, limit offset from true alignment to 1/4 inch (6 mm).
4. Location: Limit variation from plane to 1/8 inch in 12 feet (3.2 mm in 3.7 m); 1/2 inch (12.7 mm) over total length.
5. Terra Cotta Baguette Assembly/Installation Tolerance:
 - a. Where surfaces of two pieces of terra cotta abut in line, limit offset from true alignment to 1/16 inch.
 - b. Where surface of terra cotta baguette abuts with aluminum end cap, limit offset from true alignment to 1/16 inch.
 - c. For joints between baguette assemblies installed on the same curtain wall unit, limit offset from true alignment to 1/16 inch.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: **[Owner will engage] [Engage]** a qualified testing agency to perform tests and inspections.

- B. Periodic Manufacturer Inspections: Arrange for curtain wall system manufacturer's technical personnel to inspect installation during periods of ongoing installation. Provide a report of observations from the curtain wall manufacturer for each site visit.
- C. Testing Services: Testing and inspecting of representative areas of glazed aluminum curtain walls shall take place as installation proceeds to determine compliance of installed assemblies with specified requirements.
- D. Field Quality-Control Testing: Perform the following tests.
1. Perform tests before installation of interior finishes has begun.
 2. Include a minimum of 6 inches of adjacent wall construction in the testing area for each test location.
 - a. The performance of the transition to the adjacent wall assembly is considered part of the test specimen.
 3. Perform testing prior to installation of veneer cladding.
 4. Pretesting: Testing of designated test locations prior to official testing by the Testing Agency is not allowed.
 5. Additional Testing due to Rework: If rework of curtain wall areas is required to repair deficient conditions or components, additional testing above and beyond the testing list below will be required.
 - a. Number of Tests:
 - 1) Minimum number of Tests: One additional test per test type listed below.
 - 2) Maximum number of Tests: No more than 15% of the rework area.
 - 3) Final determination of test locations and quantities is at the discretion of the Architect and Owner.
 - 4) Failure criteria listed below applies to testing of rework areas.
- E. **[On-Building] [Off-Building] Performance Mockup Testing**
1. Qualitative Air-Leakage-Location Testing: Assemblies will be tested for evidence of air leakage according to ASTM E 1186, chamber pressurization or depressurization with smoke tracers.
 - a. Test Pressure: 6.24 lbf/sq.ft.
 - b. Failure Criteria: Visual evidence of air leakage by means of observations of unanticipated smoke infiltration or exfiltration.
 2. Water Penetration: Each Curtain Wall Area installed on the Site Mockup shall be tested according to ASTM E 1105 at a minimum static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than **<Insert Value>** lbf/sq. ft., and shall not evidence water penetration.
 3. Water Spray Test: Areas designated by the Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.
 - a. Test the transitions at adjacent exterior enclosure assemblies, inside/outside curtain wall corners, horizontal stack joints, split vertical mullion, sun shade brackets, and at changes in the plane of the curtain wall systems.
 4. Structural-Sealant Adhesion: Test structural sealant according to recommendations in ASTM C 1401, Destructive Test Method A, "Hand Pull Tab (Destructive)," Appendix X2.
 - a. Test a minimum of 2 areas on each Curtain Wall System type.
 - b. Repair installation areas damaged by testing.

F. In-Situ Testing

1. Water Penetration: Areas shall be tested according to ASTM E1105 at a minimum uniform static air pressure differential of 0.67 times the static air pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than <Insert Value> lb/sf, and shall not evidence water penetration.
 - a. ASTM E1105 Test Areas and Number of Tests:
 - 1) Distribute tests evenly across elevations.
 - 2) <Insert Curtain Wall Type>
 - a) Perform three (3) tests in areas as selected by the Architect.
 - b) Perform a test prior to 10 percent completion of the curtain wall installation.
 - c) Perform the second test after 10 percent completion but prior to 40 percent completion of the curtain wall installation.
 - d) Perform the third test after 40 percent completion but prior to prior to 75% completion of the curtain wall installation.
 - e) Specimen size Per Test: one unit (story) high by 2 full lites wide, including 3 full vertical mullions. **[Include the horizontal stack joint in the test area.]**
 - 3) <Insert Curtain Wall Type>
 - a) Perform three (3) tests in areas as selected by the Architect.
 - b) Perform a test prior to 10 percent completion of the curtain wall installation.
 - c) Perform the second test after 10 percent completion but prior to 40 percent completion of the curtain wall installation.
 - d) Perform the third test after 40 percent completion but prior to prior to 75% completion of the curtain wall installation.
 - e) Specimen size Per Test: one unit (story) high by 2 full lites wide, including 3 full vertical mullions. **[Include the horizontal stack joint in the test area.]**
2. Water Spray Test: Areas designated by the Architect shall be tested according to AAMA 501.2 and shall not evidence water penetration.
 - a. Test the transitions at adjacent exterior enclosure assemblies, inside/outside curtain wall corners, horizontal stack joints, split vertical mullion, sun shade brackets and at changes in the plane of the curtain wall systems.
 - b. Test amount: <Insert Value> linear feet total for all systems.
 - c. Distribute tests evenly across all elevations.
3. Splice Joint Dam Test: Areas designated by the Architect shall be tested according to AAMA 502-02 "Sill Dam Test". Testing shall not evidence water penetration. Water loss through the splice joinery during the test duration is considered a failure.
 - a. Test Locations: Splice joints in the bottom half of the horizontal stack joint mullion.
 - b. Number of Tests: Test 1% of the splice joints but not less than five.
 - c. Static Head Height: equal to specified water penetrate test pressure.
 - d. Test Duration: 15 minutes.
 - e. Distribute tests evenly across all elevations.
4. Structural-Sealant Adhesion: Test structural sealant according to recommendations in ASTM C 1401, Destructive Test Method A, "Hand Pull Tab (Destructive)," Appendix X2.
 - a. Test a minimum of four areas on each system type on each building facade.
 - b. Repair installation areas damaged by testing.

5. Infrared Evaluation:
 - a. In general accordance with ASTM C1060 to evaluate for IGU failures and missing spandrel insulation.
 - 1) If anomalies are identified, provide proposed plan to confirm source of anomalies.
 - 2) If deficiencies are identified during confirmation process, notify design team, manufacturer, and Owner of cause and extent of deficiencies.
 - 3) Submit manufacturer approved corrective action plan for Owner and Architect's review and approval.
 - 4) Perform infrared evaluation to confirm that deficiencies have been corrected.
 - b. In general accordance with ASTM E1186 to evaluate air leakage related to the curtain wall assemblies in locations such as but not limited to transitions to adjacent exterior enclosure assemblies, penetrations through spandrels, and joints within the curtain wall assembly.
 - 1) If anomalies are identified, provide proposed plan to confirm source of anomalies.
 - 2) If deficiencies are identified during confirmation process, notify design team, manufacturer, and Owner of cause and extent of deficiencies.
 - 3) Submit manufacturer approved corrective action plan for Owner and Architect's review and approval.
 - 4) Perform infrared evaluation to confirm that deficiencies have been corrected.
6. Embedded Anchor Testing:
 - a. Site Test representatives of each anchor type embedded into concrete.
 - b. Conduct testing at each floor prior to installation of curtain wall units.
 - c. Test each anchor type for shear, tension, and shear and tension combined.
 - d. Test to 1.5 times the design load.
 - e. Comply with ASTM E 488.
 - f. Test a minimum of 1 percent but no less than five (5) anchors of each anchor type.
 - g. Where anomalies in the construction are detected during visual inspections or there are failures during embed testing, test an additional minimum of 5 percent but no less than ten (10) anchors of that anchor type for that floor.
 - h. Failure or permanent deformation to the anchor or the concrete is not acceptable.
 - i. Perform tests by an approved independent testing authority. Provide plan of test areas, test procedures, remediation measures (if required) and test results for review.
- G. Glazed curtain walls will be considered defective if they do not pass tests and inspections.
 1. Upon failure of any tests:
 - a. Mockup Testing:
 - 1) Determine Cause of Failure.
 - 2) Repair per manufacturer's recommendation.
 - 3) Provide a remediation plan for review prior to performing the remediation and retesting.
 - 4) Retest specimen after repairs are complete.
 - b. In-situ Testing:
 - 1) Determine Cause of Failure.
 - 2) Provide a remediation plan for review prior to performing the remediation and retesting.
 - 3) Repair per manufacturer's recommendation.

- 4) Retest specimen after repairs are complete.
 - 5) Determine if deficient conditions are present elsewhere on the building and repair per manufacturer's recommendations.
 - 6) If Cause of Failure was due to issues related to the quality of installation or failure to follow installation instructions or shop drawings, incorporate method to ensure future compliance into the fabrication and installation quality assurance and control programs.
 - 7) Provide an additional two tests for each occurrence of a failure.
- H. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.
- I. All fees and expenses incurred by the Owner associated with the participation of the Architect, Owner, and Owner's designated technical representatives for the following conditions shall be the sole responsibility of the Contractor.
1. Observation of the repair/reconstruction of deficient conditions.
 2. Observation of re-testing of in-situ testing.
 3. Observation of additional testing at rework areas.
- J. Prepare test and inspection reports with photographs included.

END OF SECTION

SECTION 087100 - DOOR HARDWARE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes commercial door hardware for the following:
 - 1. Swinging doors.
 - 2. Other doors to the extent indicated.
- B. Door hardware includes, but is not necessarily limited to, the following:
 - 1. Mechanical door hardware.
- C. Related Sections:
 - 1. Division 01 Section "General Conditions".
 - 2. Division 06 Section "Rough Carpentry".
 - 3. Division 06 Section "Finish Carpentry".
 - 4. Division 08 Section "Operations and Maintenance".
 - 5. Division 08 Section "Hollow Metal Doors and Frames".
 - 6. Division 08 Section "Flush Wood Doors".
 - 7. Division 26 Section "Electrical".
- D. Codes and References: Comply with the version adopted by the Authority Having Jurisdiction.
 - 1. ANSI A117.1 - Accessible and Usable Buildings and Facilities.
 - 2. ICC/IBC - International Building Code.
 - 3. NFPA 70 - National Electrical Code.
 - 4. NFPA 80 - Fire Doors and Windows.
 - 5. NFPA 101 - Life Safety Code.
 - 6. NFPA 105 - Installation of Smoke Door Assemblies.
 - 7. State Building Codes, Local Amendments.
- E. Standards: All hardware specified herein shall comply with the following industry standards as applicable. Any undated reference to a standard shall be interpreted as referring to the latest edition of that standard:
 - 1. ANSI/BHMA Certified Product Standards - A156 Series.
 - 2. UL10C - Positive Pressure Fire Tests of Door Assemblies.
 - 3. ANSI/UL 294 - Access Control System Units.
 - 4. UL 305 - Panic Hardware.
 - 5. ANSI/UL 437- Key Locks.

1.3 SUBMITTALS

- A. Product Data: Manufacturer's product data sheets including installation details, material descriptions, dimensions of individual components and profiles, operational descriptions and finishes.
- B. Door Hardware Schedule: Prepared by or under the supervision of supplier, detailing, fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final Door Hardware Schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
1. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule."
 2. Organization: Organize the Door Hardware Schedule into door hardware sets indicating complete designations of every item required for each door or opening. Organize door hardware sets in same order as in the Door Hardware Sets at the end of Part 3. Submittals that do not follow the same format and order as the Door Hardware Sets will be rejected and subject to resubmission.
 3. Content: Include the following information:
 - a. Type, style, function, size, label, hand, and finish of each door hardware item.
 - b. Manufacturer of each item.
 - c. Fastenings and other pertinent information.
 - d. Location of door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
 - e. Explanation of abbreviations, symbols, and codes contained in schedule.
 - f. Mounting locations for door hardware.
 - g. Door and frame sizes and materials.
 - h. Warranty information for each product.
 - i. Operational narratives for electrified hardware.
 4. Submittal Sequence: Submit the final Door Hardware Schedule at earliest possible date, particularly where approval of the Door Hardware Schedule must precede fabrication of other work that is critical in the Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the Door Hardware Schedule.
- C. Shop Drawings: Details of electrified access control hardware indicating the following:
1. Wiring Diagrams: Upon receipt of approved schedules, submit detailed system wiring diagrams for power, signaling, monitoring, communication, and control of the access control system electrified hardware. Differentiate between manufacturer-installed and field-installed wiring. Include the following:
 - a. Elevation diagram of each unique access controlled opening showing location and interconnection of major system components with respect to their placement in the respective door openings.
 2. Point to Point Wiring Diagrams: Upon receipt of approved schedules, submit detailed system wiring diagrams for power, signaling, monitoring, communication, and control of the access control system electrified hardware. Differentiate between manufacturer-installed and field-installed wiring. Include the following:
 - a. Complete (risers, point-to-point) access control system block wiring diagrams.
 - b. Wiring instructions for each electronic component scheduled herein.

3. Electrical Coordination: Coordinate with related sections the voltages and wiring details required at electrically controlled and operated hardware openings.
 4. Provide engineered diagrams specific to each opening. Individual wiring instructions shipped with devices are not considered a complete diagram.
- D. Keying Schedule: After a keying meeting with the owner has taken place prepare a separate keying schedule detailing final instructions. Submit the keying schedule in electronic format. Include keying system explanation, door numbers, key set symbols, hardware set numbers and special instructions. Owner must approve submitted keying schedule prior to the ordering of permanent cylinders/cores.
- E. Informational Submittals:
1. Product Test Reports: Indicating compliance with cycle testing requirements, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified independent testing agency.

1.4 CLOSEOUT SUBMITTALS

- A. Operating and Maintenance Manuals: Provide manufacturers operating and maintenance manuals for each item comprising the complete door hardware installation in quantity as required in Division 01, Closeout Procedures.
- B. Project Record Documents: Provide record documentation of as-built door hardware sets in digital format (.pdf, .docx, .xlsx, .csv) and as required in Division 01, Project Record Documents.

1.5 QUALITY ASSURANCE

- A. Manufacturers Qualifications: Engage qualified manufacturers with a minimum 5 years of documented experience in producing hardware and equipment similar to that indicated for this Project and that have a proven record of successful in-service performance.
- B. Certified Products: Where specified, products must maintain a current listing in the Builders Hardware Manufacturers Association (BHMA) Certified Products Directory (CPD).
- C. Installer Qualifications: A minimum 3 years documented experience installing both standard and electrified door hardware similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- D. Door Hardware Supplier Qualifications: Experienced commercial door hardware distributors with a minimum 5 years documented experience supplying both mechanical and electromechanical hardware installations comparable in material, design, and extent to that indicated for this Project. Supplier recognized as a factory direct distributor by the manufacturers of the primary materials with a warehousing facility in Project's vicinity. Supplier to have on staff a certified Architectural Hardware Consultant (AHC) available during the course of the Work to consult with Contractor, Architect, and Owner concerning both standard and electromechanical door hardware and keying.

- E. Source Limitations: Obtain each type and variety of door hardware specified in this section from a single source unless otherwise indicated.
1. Electrified modifications or enhancements made to a source manufacturer's product line by a secondary or third party source will not be accepted.
 2. Provide electromechanical door hardware from the same manufacturer as mechanical door hardware, unless otherwise indicated.
- F. Each unit to bear third party permanent label indicating compliance with the referenced testing standards.
- G. Keying Conference: Conduct conference to comply with requirements in Division 01 Section "Project Meetings." Keying conference to incorporate the following criteria into the final keying schedule document:
1. Function of building, purpose of each area and degree of security required.
 2. Plans for existing and future key system expansion.
 3. Requirements for key control storage and software.
 4. Installation of permanent keys, cylinder cores and software.
 5. Address and requirements for delivery of keys.
- H. Pre-Submittal Conference: Conduct coordination conference in compliance with requirements in Division 01 Section "Project Meetings" with attendance by representatives of Supplier(s), Installer(s), and Contractor(s) to review proper methods and the procedures for receiving, handling, and installing door hardware.
1. Inspect and discuss electrical roughing-in, power supply connections, and other preparatory work performed by other trades.
 2. Review sequence of operation narratives for each unique access controlled opening.
 3. Review and finalize construction schedule and verify availability of materials.
 4. Review the required inspecting, testing, commissioning, and demonstration procedures
- I. Pre-Installation Conference: Conduct coordination conference in compliance with requirements in Division 01 Section "Project Meetings" with attendance by representatives of Supplier(s), Installer(s), and Contractor(s) to review proper methods and the procedures for installing door hardware.
1. Prior to installation of door hardware, door hardware supplier shall conduct a project specific training meeting to instruct the installing contractors' personnel on the proper installation and adjustment of their respective products. Product training to be attended by installers of door hardware (including electromechanical hardware) for aluminum, hollow metal and wood doors. Training will include the use of installation manuals, hardware schedules, templates and physical product samples as required.
 2. Hardware supplier shall engage factory personnel for installation training on locks, exit devices and door closers.
- J. At completion of installation, provide written documentation that components were applied according to manufacturer's instructions and recommendations and according to approved schedule.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Inventory door hardware on receipt and provide secure lock-up and shelving for door hardware delivered to Project site. Do not store electronic access control hardware, software or accessories at Project site without prior authorization.
- B. Tag each item or package separately with identification related to the final Door Hardware Schedule, and include basic installation instructions with each item or package.
- C. Deliver, as applicable, permanent keys, cylinders, cores, access control credentials, software and related accessories directly to Owner via registered mail or overnight package service. Instructions for delivery to the Owner shall be established at the "Keying Conference".

1.7 COORDINATION

- A. Templates: Obtain and distribute to the parties involved templates for doors, frames, and other work specified to be factory prepared for installing standard and electrified hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing hardware to comply with indicated requirements.
- B. Door Hardware and Electrical Connections: Coordinate the layout and installation of scheduled electrified door hardware and related access control equipment with required connections to source power junction boxes, low voltage power supplies, detection and monitoring hardware, and fire and detection alarm systems.
- C. Door and Frame Preparation: Doors and corresponding frames are to be prepared, reinforced and pre-wired (if applicable) to receive the installation of the specified electrified, monitoring, signaling and access control system hardware without additional in-field modifications.

1.8 WARRANTY

- A. General Warranty: Reference Division 01, General Requirements. Special warranties specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Warranty Period: Written warranty, executed by manufacturer(s), agreeing to repair or replace components of standard and electrified door hardware that fails in materials or workmanship within specified warranty period after final acceptance by the Owner. Failures include, but are not limited to, the following:
 - 1. Structural failures including excessive deflection, cracking, or breakage.
 - 2. Faulty operation of the hardware.
 - 3. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 4. Electrical component defects and failures within the systems operation.
- C. Warranty Period: Unless otherwise indicated, warranty shall be one year from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 MATERIALS**

- A. Hardware shall not have any visible manufacturer names on exposed materials, except cylinders, when the door is in a closed position.

2.2 BUTT HINGES

- A. Hinges: ANSI/BHMA A156.1 butt hinges with number of hinge knuckles and other options as specified in the Door Hardware Sets.
1. Quantity: Provide the following hinge quantity:
 - a. Two Hinges: For doors with heights up to 60 inches.
 - b. Three Hinges: For doors with heights 61 to 90 inches.
 - c. Four Hinges: For doors with heights 91 to 120 inches.
 - d. For doors with heights more than 120 inches, provide 4 hinges, plus 1 hinge for every 30 inches of door height greater than 120 inches.
 2. Hinge Size: Provide the following, unless otherwise indicated, with hinge widths sized for door thickness and clearances required:
 - a. Widths up to 3'0": 4-1/2" standard or heavy weight as specified.
 - b. Sizes from 3'1" to 4'0": 5" standard or heavy weight as specified.
 3. Hinge Weight and Base Material: Unless otherwise indicated, provide the following:
 - a. Exterior Doors: Heavy weight, non-ferrous, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate standard weight.
 - b. Interior Doors: Standard weight, steel, ball bearing or oil impregnated bearing hinges unless Hardware Sets indicate heavy weight.
 4. Hinge Options: Comply with the following:
 - a. Non-removable Pins: With the exception of electric through wire hinges, provide set screw in hinge barrel that, when tightened into a groove in hinge pin, prevents removal of pin while door is closed; for all out-swinging lockable doors.
 5. Manufacturers:
 - a. Hager Companies (HA) - BB Series, 5-knuckle.
 - b. Ives (IV) - 5BB Series, 5-knuckle.
 - c. McKinney (MK) - TA/T4A Series, 5-knuckle.

2.3 POWER TRANSFER DEVICES

- A. Electrified Quick Connect Transfer Hinges: Provide electrified transfer hinges with Molex™ standardized plug connectors and sufficient number of concealed wires (up to 12) to accommodate the electrified functions specified in the Door Hardware Sets with a 1-year warranty. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Wire nut connections are not acceptable.
1. Manufacturers:
 - a. Hager Companies (HA) - ETW-QC (# wires) Option.
 - b. Ives (IV) - Connect.
 - c. McKinney (MK) - QC (# wires) Option.

- B. Concealed Quick Connect Electric Power Transfers: Provide concealed wiring pathway housing mortised into the door and frame for low voltage electrified door hardware. Furnish with Molex™ standardized plug connectors and sufficient number of concealed wires (up to 12) to accommodate the electrified functions specified in the Door Hardware Sets. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Wire nut connections are not acceptable.
1. Manufacturers:
 - a. Pemko (PE) - EL-CEPT Series.
 - b. Securitron (SU) - EL-CEPT Series.
 - c. Von Duprin (VD) - EPT-10 Series.
- C. Electric Door Wire Harnesses: Provide electric/data transfer wiring harnesses with standardized plug connectors to accommodate up to twelve (12) wires. Connectors plug directly to through-door wiring harnesses for connection to electric locking devices and power supplies. Provide sufficient number and type of concealed wires to accommodate electric function of specified hardware. Provide a connector for through-door electronic locking devices and from hinge to junction box above the opening. Wire nut connections are not acceptable. Determine the length required for each electrified hardware component for the door type, size and construction, minimum of two per electrified opening.
1. Provide one each of the following tools as part of the base bid contract:
 - a. McKinney (MK) - Electrical Connecting Kit: QC-R001.
 - b. McKinney (MK) - Connector Hand Tool: QC-R003.
 2. Manufacturers:
 - a. Hager Companies (HA) - Quick Connect.
 - b. McKinney (MK) - QC-C Series.
 - c. Von Duprin (VD) - Connect.

2.4 DOOR OPERATING TRIM

- A. Flush Bolts and Surface Bolts: Provide products conforming to ANSI/BHMA A156.3 and A156.16, Grade 1.
1. Flush bolts to be furnished with top rod of sufficient length to allow bolt retraction device location approximately six feet from the floor.
 2. Furnish dust proof strikes for bottom bolts.
 3. Surface bolts to be minimum 8" in length and U.L. listed for labeled fire doors and U.L. listed for windstorm components where applicable.
 4. Provide related accessories (mounting brackets, strikes, coordinators, etc.) as required for appropriate installation and operation.
 5. Manufacturers:
 - a. Ives (IV).
 - b. Rockwood (RO).
 - c. Trimco (TC).

2.5 CYLINDERS AND KEYING

- A. General: Cylinder manufacturer to have minimum (10) years experience designing secured master key systems and have on record a published security keying system policy.

- B. Cylinder Types: Original manufacturer cylinders able to supply the following cylinder formats and types:
1. Threaded mortise cylinders with rings and cams to suit hardware application.
 2. Rim cylinders with back plate, flat-type vertical or horizontal tailpiece, and raised trim ring.
 3. Mortise and rim cylinder collars to be solid and recessed to allow the cylinder face to be flush and be free spinning with matching finishes.
 4. Keyway: Match Facility Standard.
- C. Small Format Interchangeable Cores: Provide small format interchangeable cores (SFIC) as specified, core insert, removable by use of a special key; usable with other manufacturers' cylinders.
- D. Keying System: Each type of lock and cylinders to be factory keyed.
1. Supplier shall conduct a "Keying Conference" to define and document keying system instructions and requirements.
 2. Furnish factory cut, nickel-silver large bow permanently inscribed with a visual key control number as directed by Owner.
 3. New System: Key locks to the existing key system as directed by the Owner.
- E. Key Quantity: Provide the following minimum number of keys:
1. Change Keys per Cylinder: Two (2)
 2. Master Keys (per Master Key Level/Group): Five (5).
 3. Construction Keys: Ten (10).
 4. Construction Control Keys: Two (2).
 5. Permanent Control Keys: Two (2).
- F. Construction Keying: Provide temporary keyed construction cores.
- G. Key Registration List (Bitting List):
1. Provide keying transcript list to Owner's representative in the proper format for importing into key control software.
 2. Provide transcript list in writing or electronic file as directed by the Owner.

2.6 KEY CONTROL

- A. Key Control Cabinet: Provide a key control system including envelopes, labels, and tags with self-locking key clips, receipt forms, 3-way visible card index, temporary markers, permanent markers, and standard metal cabinet. Key control cabinet shall have expansion capacity of 150% of the number of locks required for the project.
1. Manufacturers:
 - a. Lund Equipment (LU).
 - b. MMF Industries (MM).
 - c. Telkee (TK).

2.7 MORTISE LOCKS AND LATCHING DEVICES

- A. Mortise Locksets, Grade 1 (Heavy Duty): Provide ANSI/BHMA A156.13, Series 1000, Operational Grade 1 Certified Products Directory (CPD) listed mortise locksets. Listed manufacturers shall meet all functions and features as specified herein.
1. Manufacturers:
 - a. Corbin Russwin Hardware (RU) - ML2000 Series.
 - b. Sargent Manufacturing (SA) - 8200 Series.
 - c. Schlage (SC) - L9000 Series.

2.8 LOCK AND LATCH STRIKES

- A. Strikes: Provide manufacturer's standard strike with strike box for each latch or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, unless otherwise indicated, and as follows:
1. Flat-Lip Strikes: For locks with three-piece antifriction latchbolts, as recommended by manufacturer.
 2. Extra-Long-Lip Strikes: For locks used on frames with applied wood casing trim.
- B. Standards: Comply with the following:
1. Strikes for Mortise Locks and Latches: BHMA A156.13.
 2. Dustproof Strikes: BHMA A156.16.

2.9 CONVENTIONAL EXIT DEVICES

- A. General Requirements: All exit devices specified herein shall meet or exceed the following criteria:
1. Exit devices shall have a five-year warranty.
 2. At doors not requiring a fire rating, provide devices complying with NFPA 101 and listed and labeled for "Panic Hardware" according to UL305. Provide proper fasteners as required by manufacturer including sex nuts and bolts at openings specified in the Hardware Sets.
 3. Where exit devices are required on fire rated doors, provide devices complying with NFPA 80 and with UL labeling indicating "Fire Exit Hardware". Provide devices with the proper fasteners for installation as tested and listed by UL. Consult manufacturer's catalog and template book for specific requirements.
 4. Except on fire rated doors, provide exit devices with hex key dogging device to hold the pushbar and latch in a retracted position. Provide optional keyed cylinder dogging on devices where specified in Hardware Sets.
 5. Devices must fit flat against the door face with no gap that permits unauthorized dogging of the push bar. The addition of filler strips is required in any case where the door light extends behind the device as in a full glass configuration.
 6. Lever Operating Trim: Where exit devices require lever trim, furnish manufacturer's heavy duty escutcheon trim with threaded studs for thru-bolts.
 - a. Lock Trim Design: As indicated in Hardware Sets, provide finishes and designs to match that of the specified locksets.
 - b. Where function of exit device requires a cylinder, provide a cylinder (Rim or Mortise) as specified in Hardware Sets.

7. Vertical Rod Exit Devices: Where surface or concealed vertical rod exit devices are used at interior openings, provide as less bottom rod (LBR) unless otherwise indicated. Provide dust proof strikes where thermal pins are required to project into the floor.
 8. Narrow Stile Applications: At doors constructed with narrow stiles, or as specified in Hardware Sets, provide devices designed for maximum 2" wide stiles.
 9. Dummy Push Bar: Nonfunctioning push bar matching functional push bar.
 10. Rail Sizing: Provide exit device rails factory sized for proper door width application.
 11. Through Bolt Installation: For exit devices and trim as indicated in Door Hardware Sets.
- B. Conventional Push Rail Exit Devices (Heavy Duty): ANSI/BHMA A156.3, Grade 1 Certified Products Directory (CPD) listed exit devices. Listed manufacturers shall meet all functions and features as specified herein.
1. Manufacturers:
 - a. Corbin Russwin Hardware (RU) - ED5000 Series.
 - b. Sargent Manufacturing (SA) - 80 Series.
 - c. Von Duprin (VD) - 98 Series.

2.10 SURFACE DOOR CLOSERS

- A. All door closers specified herein shall meet or exceed the following criteria:
1. General: Door closers to be from one manufacturer, matching in design and style, with the same type door preparations and templates regardless of application or spring size. Closers to be non-handed with full sized covers.
 2. Standards: Closers to comply with UL-10C for Positive Pressure Fire Test and be U.L. listed for use of fire rated doors.
 3. Size of Units: Comply with manufacturer's written recommendations for sizing of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Where closers are indicated for doors required to be accessible to the Americans with Disabilities Act, provide units complying with ANSI ICC/A117.1.
 4. Closer Arms: Provide heavy duty, forged steel closer arms unless otherwise indicated in Hardware Sets.
 5. Closers shall not be installed on exterior or corridor side of doors; where possible install closers on door for optimum aesthetics.
 6. Closer Accessories: Provide door closer accessories including custom templates, special mounting brackets, spacers and drop plates as required for proper installation. Provide through-bolt and security type fasteners as specified in the hardware sets.
- B. Door Closers, Surface Mounted (Large Body Cast Iron): ANSI/BHMA A156.4, Grade 1 Certified Products Directory (CPD) listed surface mounted, heavy duty door closers with complete spring power adjustment, sizes 1 thru 6; and fully operational adjustable according to door size, frequency of use, and opening force. Closers to be rack and pinion type, one piece cast iron body construction, with adjustable backcheck and separate non-critical valves for closing sweep and latch speed control.
1. Manufacturers:
 - a. Corbin Russwin Hardware (RU) - DC8000 Series.
 - b. LCN Closers (LC) - 4040XP Series.
 - c. Sargent Manufacturing (SA) - 281 Series.

2.11 SURFACE MOUNTED CLOSER HOLDERS

- A. Electromagnetic Door Holders: ANSI A156.15, Grade 1 electromagnetic door holder/releases with a minimum 25 to 40 pounds holding power and fail-safe operation; power failure releases door to close.
 - 1. Manufacturers:
 - a. LCN Door Closers (LC) - SEM7800 Series.
 - b. Norton Rixson (NO) - 900 Series.
 - c. Sargent Manufacturing (SA) - 1560 Series.

2.12 ARCHITECTURAL TRIM AND ACCESSORIES

- A. Door, Frame and Wall Protective Trim: ANSI/BHMA A156.6, protective products as specified in the hardware sets. Door protection plates shall be not more than 2" less than door width on stop side and 1" less door width on the pull side or on stop side of pairs of doors. Listed manufacturers shall meet all functions and features as specified herein.
 - 1. Provide protective trim with functions and features as follows:
 - a. Meets ADA requirements for smooth bottom door surfaces.
 - b. UL Classified options for use on fire-rated doors up to 3 hours.
 - c. Fabricated from stainless steel, brass, bronze, aluminum, or high-impact plastic.
 - d. Available in a variety of sizes, finishes, and profiles to suit aesthetic and functional requirements.
 - e. Designed to protect doors, frames, and adjacent walls from damage due to impact, abrasion, or traffic.
 - f. Fasteners included; adhesive-backed options available for select models.
 - g. Ten-year limited warranty.
 - 2. Manufacturers:
 - a. Ives (IV).
 - b. Rockwood (RO).
 - c. Trimco (TC).

2.13 DOOR STOPS AND HOLDERS

- A. Door Stops and Bumpers: ANSI/BHMA A156.16, Grade 1 door stops and wall bumpers. Provide wall bumpers, either convex or concave types with anchorage as indicated, unless floor or other types of door stops are specified in Hardware Sets. Do not mount floor stops where they will impede traffic. Where floor or wall bumpers are not appropriate, provide overhead type stops and holders.
 - 1. Manufacturers:
 - a. Ives (IV).
 - b. Rockwood (RO).
 - c. Trimco (TC).

2.14 ARCHITECTURAL SEALS

- A. General: Thresholds, weatherstripping, and gasket seals to be of type and design as specified below or in the Hardware Sets. Provide continuous weatherstrip gasketing on exterior doors and provide smoke, light, or sound gasketing on interior doors where indicated. At exterior applications provide non-corrosive fasteners and elsewhere where indicated.

- B. Smoke Labeled Gasketing: Assemblies complying with NFPA 105 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for smoke control ratings indicated, based on testing according to UL 1784.
 - 1. Provide smoke labeled perimeter gasketing at all smoke labeled openings.
- C. Fire Labeled Gasketing: Assemblies complying with NFPA 80 that are listed and labeled by a testing and inspecting agency acceptable to authorities having jurisdiction, for fire ratings indicated, based on testing according to UL-10C.
 - 1. Provide intumescent seals as indicated to meet UL10C Standard for Positive Pressure Fire Tests of Door Assemblies, and NFPA 252, Standard Methods of Fire Tests of Door Assemblies.
- D. Sound-Rated Gasketing: Assemblies that are listed and labeled by a testing and inspecting agency, for sound ratings indicated.
- E. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.
- F. Manufacturers:
 - 1. Pemko (PE).
 - 2. Reese Enterprises, Inc. (RE).
 - 3. Zero (ZE).

2.15 FABRICATION

- A. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to manufacturers recognized installation standards for application intended.

2.16 FINISHES

- A. Standard: Designations used in the Hardware Sets and elsewhere indicate hardware finishes complying with ANSI/BHMA A156.18, including coordination with traditional U.S. finishes indicated by certain manufacturers for their products.
- B. Provide quality of finish, including thickness of plating or coating (if any), composition, hardness, and other qualities complying with manufacturer's standards, but in no case less than specified by referenced standards for the applicable units of hardware
- C. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine scheduled openings, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.

- B. Notify architect of any discrepancies or conflicts between the door schedule, door types, drawings and scheduled hardware. Proceed only after such discrepancies or conflicts have been resolved in writing.

3.2 PREPARATION

- A. Hollow Metal Doors and Frames: Comply with ANSI/DHI A115 series.
- B. Wood Doors: Comply with ANSI/DHI A115-W series.

3.3 INSTALLATION

- A. Install each item of mechanical and electromechanical hardware and access control equipment to comply with manufacturer's written instructions and according to specifications.
 - 1. Installers are to be trained and certified by the manufacturer on the proper installation and adjustment of fire, life safety, and security products including: hanging devices; locking devices; closing devices; and seals.
- B. Mounting Heights: Mount door hardware units at heights indicated in following applicable publications, unless specifically indicated or required to comply with governing regulations:
 - 1. Standard Steel Doors and Frames: DHI's "Recommended Locations for Architectural Hardware for Standard Steel Doors and Frames."
 - 2. DHI TDH-007-20: Installation Guide for Doors and Hardware.
 - 3. Where indicated to comply with accessibility requirements, comply with ANSI A117.1 "Accessibility Guidelines for Buildings and Facilities."
 - 4. Provide blocking in drywall partitions where wall stops or other wall mounted hardware is located.
- C. Retrofitting: Install door hardware to comply with manufacturer's published templates and written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 9 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.
- D. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant complying with requirements specified in Division 7 Section "Joint Sealants."
- E. Storage: Provide a secure lock up for hardware delivered to the project but not yet installed. Control the handling and installation of hardware items so that the completion of the work will not be delayed by hardware losses before and after installation.

3.4 FIELD QUALITY CONTROL

- A. Field Inspection (Punch Report): Reference Division 01 Sections "Closeout Procedures". Produce project punch report for each installed door opening indicating compliance with approved submittals and verification hardware is properly installed, operating and adjusted. Include list of items to be completed and corrected, indicating the reasons or deficiencies causing the Work to be incomplete or rejected.

1. Organization of List: Include separate Door Opening and Deficiencies and Corrective Action Lists organized by Mark, Opening Remarks and Comments, and related Opening Images and Video Recordings.

3.5 ADJUSTING

- A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

3.6 CLEANING AND PROTECTION

- A. Protect all hardware stored on construction site in a covered and dry place. Protect exposed hardware installed on doors during the construction phase. Install any and all hardware at the latest possible time frame.
- B. Clean adjacent surfaces soiled by door hardware installation.
- C. Clean operating items as necessary to restore proper finish. Provide final protection and maintain conditions that ensure door hardware is without damage or deterioration at time of owner occupancy.

3.7 DEMONSTRATION

- A. Instruct Owner's maintenance personnel to adjust, operate, and maintain mechanical and electromechanical door hardware.

3.8 DOOR HARDWARE SETS

- A. The hardware sets represent the design intent and direction of the owner and architect. They are a guideline only and should not be considered a detailed hardware schedule. Discrepancies, conflicting hardware and missing items should be brought to the attention of the architect with corrections made prior to the bidding process. Omitted items not included in a hardware set should be scheduled with the appropriate additional hardware required for proper application and functionality.
 1. Quantities listed are for each pair of doors, or for each single door.
 2. The supplier is responsible for handing and sizing all products.
 3. Where multiple options for a piece of hardware are given in a single line item, the supplier shall provide the appropriate application for the opening.
- B. Manufacturer's Abbreviations:

1. IV - Ives
2. VO - Von Duprin
3. RO - Rockwood
4. SC - Schlage
5. SA - SARGENT

- 6. NO - Norton Rixson
- 7. PE - Pemko
- 8. MK - McKinney
- 9. OT - Other

Hardware Sets

Set: 1.0

Doors: 100A, 101A, 100B (SINGLE DOOR, SIMILAR)

Description: Pair Exterior Service Dock (CR, MHO)

5 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" NRP	630	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	630	IV
2 Flush Bolt	555	US26D	RO
1 Dust Proof Strike	570	US26D	RO
1 Fail Secure Lock	L9092EU H 06A 10-072-7/8 RX	630	SC
1 Permanent Core	By Owner	626	SC
2 Surface Closer	281 P10	EN	SA
2 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
2 Stop Holder	494S	US26D	RO
1 Astragal	357SP		PE
1 Gasketing	2891AS (Head)		PE
1 Gasketing	290AS (Jambs)		PE
1 Rain Guard	346C		PE
2 Sweep	315CN		PE
1 Threshold	2705AT		PE
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
1 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes: Install perimeter seal prior to closer. Special templating required. Template closer for 180 degrees. Mount astragal on pull side of active leaf and size doors for 1/8" clearance between leaves.

Operation:

- Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
- Egress always free from inside by depressing inside lever.
- Request to exit switch in lever to signal authorized egress to the access control system.
- Door position switch to signal door open/closed to the access control system.

Set: 2.0

Doors: B1EL1, B1EL2

Description: Single Exterior Electrical (CR)

3 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" NRP	630	IV
1 Electric Power Transfer	EPT10 CON	689	VO

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

1	Rim Exit Nightlatch	RX LC 98 L M CON FSE 996L 06	630	VO
1	SFIC Rim Cylinder	80-129	626	SC
1	Permanent Core	By Owner	626	SC
1	Surface Closer	281 CPS	EN	SA
1	Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1	Gasketing	2891AS (Head & Jambs)		PE
1	Rain Guard	346C		PE
2	Sweep	315CN		PE
1	Threshold	2705AT		PE
1	Wire Harness	CON Series x Length as Req'd (Door)		SC
1	Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1	Card Reader	Provided by ACS		OT
1	Door Position Switch	Provided by ACS		OT
1	Power Supply	Provided by ACS		OT

Notes: Install perimeter seal prior to closer, exit device, and strike. Special templating required.

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When devices are locked the card reader grants access upon presentation of a valid credential. Exit devices mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside push pad.
3. Request to exit switch in push pad to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 3.0

Doors: 1CR2B, 1CR2C

Description: Single Exterior Corridor (CR)

2	Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" NRP	630	IV
1	Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	630	IV
1	Fail Secure Lock	L9092EU H 06A RX	630	SC
1	Permanent Core	By Owner	626	SC
1	Surface Closer	281 CPS	EN	SA
1	Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1	Gasketing	2891AS (Head)		PE
1	Gasketing	290AS (Jambs)		PE
1	Rain Guard	346C		PE
2	Sweep	315CN		PE
1	Threshold	2705AT		PE
1	Wire Harness	CON Series x Length as Req'd (Door)		SC
1	Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1	Card Reader	Provided by ACS		OT
1	Door Position Switch	Provided by ACS		OT
1	Power Supply	Provided by ACS		OT

Notes: Install perimeter seal prior to closer. Special templating required.

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.

National Zoological Conservation Biology Institute (NZCBI)

Construct Arabian Leopard Facility (ALF)

DOOR HARDWARE

Phase 2 – Habitat & Animal Bldg

65% Construction Documents

08 7100 - 16

2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 4.0

Doors: B1ME1

Description: Pair Exterior Mechanical (CR)

5 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" NRP	630	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx	630	IV
2 Flush Bolt	555	US26D	RO
1 Dust Proof Strike	570	US26D	RO
1 Fail Secure Lock	L9092EU H 06A 10-072-7/8 RX	630	SC
1 Permanent Core	By Owner	626	SC
1 Surface Closer	281 P10	EN	SA
1 Surface Closer	281 CPS	EN	SA
2 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1 Wall Stop	406	US32D	RO
1 Astragal	357SP		PE
1 Gasketing	2891AS (Head)		PE
1 Gasketing	290AS (Jambs)		PE
1 Rain Guard	346C		PE
2 Sweep	315CN		PE
1 Threshold	2705AT		PE
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
2 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes: Mount astragal on pull side of active leaf and size doors for 1/8" clearance between leaves. Install perimeter seal prior to closer. Special templating required.

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 5.0

Doors: 1CR2A, B1AV1

Description: Single AV, Corridor (CR)

2 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" NRP	652	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	652	IV
1 Fail Secure Lock	L9092EU H 06A RX	630	SC
1 Permanent Core	By Owner	626	SC
1 Surface Closer	281 CPS	EN	SA

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

1 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
3 Silencer	608-RKW		RO
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
1 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes:

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 6.0

Doors: 101

Description: Single Custodial (CR)

2 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2"	652	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	652	IV
1 Fail Secure Lock	L9092EU H 06A RX	630	SC
1 Permanent Core	By Owner	626	SC
1 Surface Closer	281 O	EN	SA
1 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1 Wall Stop	406	US32D	RO
1 Sweep	315CN		PE
1 Threshold	171A		PE
3 Silencer	608-RKW		RO
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
1 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes:

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 7.0

Doors: 1CR3

Description: Pair Corridor (CR)

National Zoological Conservation Biology Institute (NZCBI)
Construct Arabian Leopard Facility (ALF)
DOOR HARDWARE

Phase 2 – Habitat & Animal Bldg
65% Construction Documents
08 7100 - 18

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

5 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2"	652	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	652	IV
2 Flush Bolt	555	US26D	RO
1 Dust Proof Strike	570	US26D	RO
1 Fail Secure Lock	L9092EU H 06A RX	630	SC
1 Permanent Core	By Owner	626	SC
2 Surface Closer	281 P10	EN	SA
2 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
2 Wall Stop	406	US32D	RO
1 Astragal	357SP		PE
2 Silencer	608-RKW		RO
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
2 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes: Template closer for maximum degree of opening. Mount astragal on push side of inactive leaf and size doors for 1/8" clearance between leaves.

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 8.0

Doors: 108, 1CR1

Description: Pair Corridor, Dayroom (CR)

5 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2"	652	IV
1 Hinge, Full Mortise, Hvy Wt	5BB1HW 4-1/2" x 4-1/2" TWxx CON	652	IV
2 Flush Bolt	555	US26D	RO
1 Dust Proof Strike	570	US26D	RO
1 Fail Secure Lock	L9092EU H 06A RX	630	SC
1 Permanent Core	By Owner	626	SC
2 Surface Closer	281 CPS	EN	SA
2 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1 Astragal	357SP		PE
2 Silencer	608-RKW		RO
1 Wire Harness	CON Series x Length as Req'd (Door)		SC
1 Wire Harness	CON Series x Length as Req'd (Jamb)		SC
1 Card Reader	Provided by ACS		OT
2 Door Position Switch	Provided by ACS		OT
1 Power Supply	Provided by ACS		OT

Notes: Mount astragal on push side of inactive leaf and size doors for 1/8" clearance between leaves.

Operation:

1. Doors electrically unlocked or locked during established time zones as programmed by the access control system. When outside lever is locked the card reader grants access upon presentation of a valid credential. Locksets mechanically lock during power failure with a mechanical key override entry.
2. Egress always free from inside by depressing inside lever.
3. Request to exit switch in lever to signal authorized egress to the access control system.
4. Door position switch to signal door open/closed to the access control system.

Set: 9.0

Doors: 1WC1

Description: Single Restroom

3 Hinge, Full Mortise	5BB1 4-1/2" x 4-1/2"	652	IV
1 Privacy Lock	L9040 06A OS-OCC 09-509xL583-363	630	SC
1 Surface Closer	281 O	EN	SA
1 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1 Wall Stop	406	US32D	RO
3 Silencer	608-RKW		RO

Set: 10.0

Doors: 1CS1

Description: Single Custodial

3 Hinge, Full Mortise	5BB1 4-1/2" x 4-1/2"	652	IV
1 Storeroom Lock	L9080 H 06A	630	SC
1 Permanent Core	By Owner	626	SC
1 Surface Closer	281 O	EN	SA
1 Kick Plate	K1050 10" x 2" LDW CSK BEV	US32D	RO
1 Wall Stop	406	US32D	RO
3 Silencer	608-RKW		RO

END OF SECTION

SECTION 08 8000 - GLAZING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:
 - 1. Windows.
 - 2. Doors.
 - 3. Glazed curtain walls.
 - 4. Storefront framing.
 - 5. Interior borrowed lites.
 - 6. Glazing sealants and accessories.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
 - 2. Section 08 4400 "Glazed Curtain Walls" for structural glazing sealants used in structural-sealant-glazed curtain walls.
 - 3. Section 08 8853 "Security Glazing."

1.2 DEFINITIONS

- A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.
- B. Glass Fabrication: Using primary glass in the production of single pane glass products such as coated, laminated and heat treated glass. Can be done by either the Glass Manufacturer or the Glazing Product Manufacturer.
- C. Glazing Product Manufacturer: Firm that uses fabricated glass in the production of insulating glass (multiple panes of glass).
- D. Glass Thicknesses: Indicated by thickness designations in millimeters in accordance with ASTM C1036.
- E. IBC: International Building Code.
- F. Interspace: Space between lites of an insulating-glass unit.
- G. Large Glass Lites and Insulating Glass Units: Over 55 SF.
- H. Structural Glazing Product Manufacturer: Firm that produces insulating glass for use in a structural glazing system.
- I. Wildland-Urban Interface (WUI): The zone of transition between unoccupied land and human development. It is the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. (FEMA definition)

1.3 COORDINATION

- A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review temporary protection requirements for glazing during and after installation.
 - 3. Review glazing systems included in Project and specified in other Sections.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of glass product and glazing material specified.
- B. Sustainable Design Submittals:
 - 1. Product Data: For sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings:
 - 1. Submit shop drawings of glazing details. Draw details minimum full size (twice full size preferred) and indicate dimensions, tolerances, and materials.
 - 2. Submit shop drawings for structural sealant glazing after review and approval of shop drawings by sealant and glass product manufacturers.
- D. Glass Samples:
 - 1. Each type of monolithic[**and laminated glass**], except clear monolithic glass, no less than 3 by 6 inches (75 by 160 mm).
 - 2. Each type of insulating[**and insulating laminated glass**], no less than 12 by 12 inches (300 by 300 mm), including type of edge seal, spacer, and corner construction of spacer. Identify specific type of reflective and Low-e coated glass, coated surfaces, and exterior face of unit.
 - 3. Each type of spandrel glass, no less than 12 by 12 inches (300 by 300 mm).
- E. Exposed Glazing Accessory Samples: For gaskets, sealants, and colored spacers, in 12 inch (300 mm) lengths. Install sealant samples between two strips of material representative in color of the adjoining framing system after sealant color selections have been made.
- F. Other Glazing Accessory Samples:
 - 1. Corner construction of compression gasket for dry glazing with each leg approximately 6 inches (150 mm) long.
 - 2. Tape sealant, 6 inches (150 mm) long.
 - 3. Compression wedge, 6 inches (150 mm) long.
 - 4. Channel gasket, 6 inches (150 mm) long.
 - 5. Bed gasket, 6 inches (150 mm) long.
 - 6. Face shim or spacer.
 - 7. Setting block.

8. Edge block.
 9. Compressible filler.
 10. Open cell filler.
- G. Glazing Schedule: List glass types and thicknesses for each size opening and location. Use same designations indicated on Drawings.
- H. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
1. Provide delegated-design submittals for glass.
- I. Qualification Data: For **[Installer]** **[manufacturers of insulating-glass units with sputter-coated, low-E coatings]** **[glass testing agency]** **[and]** **[sealant testing agency]**.
- J. Product Certificates:
1. Submit statement from glazing product manufacturer stating that glazing products meet the requirements of the specified standards, the project specifications, and that there is no incompatibility of glazing materials with the insulating glass unit sealants.
 2. Provide glass fabrication manufacturer's statement that they have reviewed and approved the application of the glazing details for the project.
 3. Upon request, submit reports indicating results of distortion and flatness monitoring and inspection for laminated and heat treated glass and for continuous on-line color measurement via spectrophotometer inspection device.
 4. Submit statement from structural glazing product manufacturer indicating the following:
 - a. The details of construction have been reviewed and are approved for use with the glass products.
 - b. The secondary seal of insulating glass units has been designed and sized to resist the applied loads.
 - c. The Contractor's quality assurance program has been reviewed and is approved.
 5. Submit statement from structural glazing sealant manufacturer indicating that structural sealants have been tested prior to installation and conform to the requirements of the Contract Documents and the following:
 - a. The structural sealant meets ASTM C1184.
 - b. The structural sealant is compatible with specified sealant backing and spacer materials as determined by ASTM C1087.
 - c. The structural sealant is compatible with and does not adhere to specified bond breaker and spacer materials as determined by ASTM C1087.
 - d. The structural sealant is compatible with the insulating glass unit edge seal.
 - e. The structural sealant is compatible with and has been tested for adequate adhesion to each respective substrate.
 - f. The details of construction have been reviewed and are approved for use with the structural sealant.
 - g. The design stress of the sealant due to the application of the primary forces does not exceed 20 psi (138 kPa).
 6. If any of the above required statements involve more than one manufacturer, submit certificates from each of those manufacturers.
- K. Glazing Analysis:

1. For exterior glazing, provide statement, analysis methods, and calculations that demonstrates the products meet the specified glass breakage probability requirements for indicated and anticipated in-service applied loads and demonstrating that expected thermal stressing of products is acceptable. All such analysis shall be performed by experts experienced in analyzing thermal stressing of glazing due to in service environmental conditions utilizing appropriate engineering means of thermal stress analysis.
2. For exterior glazing, provide an analysis confirming all in service thermal stressing of the glass has been evaluated and that expected thermal stressing will not exceed the strength capacity of the glass and the glass is acceptable for the anticipated in-service conditions of exposure. All such analysis shall be performed by experts experienced in analyzing thermal stressing of glazing due to in service environmental conditions utilizing appropriate engineering means of thermal stress analysis.
 - a. Provide copy of analysis and summary report.
 - b. Analysis shall include consideration for the following conditions where applicable:
 - 1) Thermal properties of the glass units, including laminate interlayers, coatings and applied frits, and thermal spacers in the case of insulated units.
 - 2) Geographic and weather conditions of the building site.
 - 3) Solar orientation of the glass units.
 - 4) Impact of shading by adjacent structures.
 - 5) Glazing system's properties that may impact temperature differentials within the glass units.
 - 6) Highly reflective surfaces in the immediate area which may impact temperature differentials within the glass units.
 - 7) Shading of glass units by properties of the building configuration including, but not limited to, fins, projections, changes in building lines in plan, overhangs, projections, and similar physical attributes.
 - 8) Glazing conditions including spandrels and shadow boxes including back pans and insulation layers on the inboard side of the glass.
 - 9) Interior conditions nearby the glass which may impact glazing unit temperatures including pockets resulting from interior configurations, interior shading or other window treatment devices, and mechanical heating or cooling systems.
 - 10) Consideration for potential loss of strength of glass due to application of frits or coatings.
 - 11) Industry standard ranges of strength for annealed, heat strengthened, or tempered glass units unless fabricator/manufacturer can demonstrate strength properties outside of these ranges.
 - 12) Consideration for predictability of post fabrication heat forming of glass units.
 - 13) Heated framing systems.
- L. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for **[tinted glass]** **[coated glass]** **[insulating glass]** **[glazing sealants]** **[and]** **[glazing gaskets]**.
 1. For glazing sealants, provide test reports based on testing current sealant formulations within previous 36-month period.
- M. Preconstruction adhesion and compatibility test report.
- N. Quality Assurance Program (QAP):

1. Glass fabrication: Written QAP including but not limited to reference of applicable ASTM testing methodology, type and frequency of in-line monitoring of glass fabrication, and reporting and documentation. Test sample lite of glass, at Contractor's expense, for conformance to:
 - a. Bow and warp.
 - b. Localized distortion/roller wave.
 - c. Concavity/convexity.
 - d. Compression strength.
 - e. Distortion and Flatness Monitoring and Inspection Device for Laminated and Heat Treated Glass: Osprey 8 by LiteSentry.
2. Installation: Written QAP to monitor quality of products such as cleaners, solvents, primers, and sealants; and sealant workmanship including, cleaning, priming, joint opening preparation, and sealant installation.
 - a. Include as part of program random adhesion and compatibility testing of production run products.
 - b. Do not install sealant work prior to review of program.
 - c. Submit quality assurance program to glass and sealant manufacturers for review and approval prior to submission to Architect.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. At Owner's direction, and prior to construction completion, furnish for future maintenance and repair, the following glass types for attic stock:
 1. **<Insert Types>**.
 2. Furnish **<Insert>** percent of quantity for each size and type but not less than 1, nor more than **<Insert>** units for each size of each type of rectangular shaped units.
- B. Units for attic stock shall be adequately crated and identified as to storage conditions, unit type, size, surface to be glazed to exterior, and any other pertinent information to assist the Owner in future maintenance.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications for Insulating-Glass Units with Sputter-Coated, Low-E Coatings: A qualified insulating-glass manufacturer who is approved[**and certified**] by coated-glass manufacturer.
- B. Glass Testing Agency Qualifications: A qualified independent testing agency accredited in accordance with the NFRC CAP 1 Certification Agency Program.
- C. Sealant Testing Agency Qualifications: An independent testing agency qualified in accordance with ASTM C1021 to conduct the testing indicated.
- D. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and to set quality standards for materials and execution.
 1. Glazing mock-up: Produce **[three]** **<insert number>** full-sized IGUs for review and approval by the Architect before full production run.
 2. Install glazing in mockups specified in Division 08 Section "[**Aluminum-Framed Entrances and Storefronts**] [**Aluminum Windows**] [**Glazed Aluminum Curtain Walls**] **<Insert Section title>**" to match glazing systems required for Project, including glazing methods.

3. Approved sample installation may become part of the completed Work if undisturbed at time of Substantial Completion.
4. Place mockup where reflection from adjacent buildings or other structures with a regular pattern can be used to gauge overall appearance / distortion of the glass.

1.8 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Test each glass product, tape sealant, gasket, glazing accessory, and glass-framing member for adhesion to and compatibility with elastomeric glazing sealants.
 1. Testing is not required if data are submitted based on previous testing of current sealant products and glazing materials matching those submitted.
 2. Use ASTM C1087 to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to glass, tape sealants, gaskets, and glazing channel substrates.
 3. Test no fewer than **[eight]** **<Insert number>** Samples of each type of material, including joint substrates, shims, sealant backings, secondary seals, and miscellaneous materials.
 4. Schedule enough time for testing and analyzing results to prevent delaying the Work.
 5. For materials failing tests, submit sealant manufacturer's written instructions for corrective measures including the use of specially formulated primers.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect glazing materials in accordance with manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.
- B. Comply with insulating-glass manufacturer's written instructions for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.10 FIELD CONDITIONS

- A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.
 1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or are below 40 deg F (4.4 deg C). Do not install sealants to wet or frost covered surfaces.

1.11 WARRANTY

- A. General: During the warranty period, restore defective Work to the standard of the Contract Documents, including all labor, materials, refinishing and other costs incidental to the Work. Restore Work found to be defective as defined in the Contract Documents. The warranty period starts at the date of Substantial Completion.
- B. Manufacturer's Special Warranty for Coated-Glass Products: Manufacturer agrees to replace coated-glass units that deteriorate within specified warranty period. Deterioration of coated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.

1. Warranty Period: [10] <Insert number> years from date of Substantial Completion.
- C. Manufacturer's Special Warranty for Laminated Glass: Manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
 1. Warranty Period: [Five] [10] <Insert number> years from date of Substantial Completion.
- D. Manufacturer's Special Warranty for Insulating Glass: Manufacturer agrees to replace insulating-glass units that deteriorate within specified warranty period. Deterioration of insulating glass is defined as failure of hermetic seal under normal use that is not attributed to glass breakage or to maintaining and cleaning insulating glass contrary to manufacturer's written instructions. Evidence of failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glass.
 1. Warranty Period: [10] <Insert number> years from date of Substantial Completion.
- E. Manufacturer's Special Warranty for Heat Soaking of Tempered Glass: Manufacturer agrees to replace heat soaked tempered glass units that fail. Warrant that heat soaked tempered glass will not spontaneously break as a result of nickel sulfide (NiS) inclusions at a rate exceeding 0.3 percent (3/1000).
 1. Warranty Period: 10 years from date of Substantial Completion.
- F. Installation: Glazing systems installation shall be warranted for a period of five years against defective materials and workmanship.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND FABRICATORS

- A. Glazing and Coating Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AGC Glass Company North America, Inc.
 2. Cardinal Glass Industries.
 3. Gardner Glass, Inc.
 4. GGI, General Glass International.
 5. Guardian Glass.
 6. Pilkington North America.
 7. Schott North America, Inc.
 8. Vetrotech Saint-Gobain.
 9. Saint-Gobain.
 10. Viracon, Inc.
 11. Vitro Architectural Glass.
- B. Glazing Unit Fabricators: Subject to compliance with requirements, provide products by one of the following:
 1. Agnora.
 2. Cardinal Glass Industries.
 3. Cristacurva.

4. Dlubak Corporation.
5. GGI; General Glass International.
6. Glasswerks LA, Inc.
7. JE Berkowitz, LP.
8. Northwestern Industries, Inc.
9. Oldcastle BuildingEnvelope.
10. Pilkington North America.
11. Rochester Insulating Glass.
12. Trulite Glass & Aluminum Solutions, LLC.
13. Tvitec.
14. Vetrotech Saint-Gobain.
15. Viracon, Inc.

- C. Source Limitations for Glass: Obtain from single source from single manufacturer for each glass type.
 1. Obtain tinted glass from single source from single manufacturer.
 2. Obtain reflective-coated glass from single source from single manufacturer.
- D. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.

2.2 PERFORMANCE REQUIREMENTS

- A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.
- B. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design glazing.
 1. Material properties indicated in this Section shall be considered as minimum properties.
- C. Structural Performance: Glazing shall withstand the following design loads within limits and under conditions indicated determined in accordance with the IBC and ASTM E1300.
 1. Design Wind Pressures:
 - a. As indicated on Drawings.
 - b. Design Wind Pressures: Determine design wind pressures applicable to Project in accordance with ASCE/SEI 7, based on heights above grade indicated on Drawings.
 - 1) Wind Design Data: As indicated on Drawings.
 - 2) Basic Wind Speed: [85 mph (38 m/s)] [90 mph (40 m/s)] [100 mph (44 m/s)] [110 mph (49 m/s)] <Insert value>.
 - 3) Importance Factor: [1.0] <Insert factor>.
 - 4) Exposure Category: [B] [C] [D].
 2. Design Snow Loads: <Insert design snow load> [As indicated on Drawings].
 3. Thickness of Patterned Glass: Base design of patterned glass on thickness at thinnest part of the glass.
 4. Probability of Breakage for Sloped Glazing: For glass surfaces sloped more than 15 degrees from vertical, design glass for a probability of breakage not greater than 0.001.

5. Maximum Lateral Deflection: For glass supported on all four edges, limit center-of-glass deflection at design wind pressure to not more than 1/50 times the short-side length or 1 inch (25 mm), whichever is less.
 6. Differential Shading: Design glass to resist thermal stresses induced by differential shading within individual glass lites.
- D. Windborne-Debris Impact Resistance: Exterior glazing shall pass ASTM E1886 missile-impact and cyclic-pressure tests in accordance with ASTM E1996 for Wind Zone [1] [2] [3] [4] for [basic] [enhanced] protection.
1. Large-Missile Test: For glazing located within [30 feet (9.1 m)] <Insert dimension> of grade.
 2. Small-Missile Test: For glazing located between 30 feet (9.1 m) and [60 feet (18.3 m)] <Insert dimension> above grade.
- E. Safety Glazing:
1. CPSC 16 CFR part 1201, testing requirements of ANSI Z97.1, and listed in the SGCC Certified Products Directory with appropriate SGCC certification mark or label permanently affixed.
 2. Furnish safety glass for glass occurring in doors and sidelights, and where indicated and further required by authorities having jurisdiction.
- F. Sound Control Glazing: Products with air borne sound transmission loss as measured by ASTM E90 and STC rating as classified by ASTM E413.
- G. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:
1. For monolithic-glass lites, properties are based on units with lites [6 mm thick] [of thickness indicated].
 2. For laminated-glass lites, properties are based on products of construction indicated.
 3. For insulating-glass units, properties are based on units of thickness indicated for overall unit and for each lite.
 4. U-Factors: Center-of-glazing values, in accordance with NFRC 100 and based on LBL's WINDOW 5.2 computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).
 5. Solar Heat-Gain Coefficient and Visible Transmittance: Center-of-glazing values, in accordance with NFRC 200 and based on LBL's WINDOW 5.2 computer program.
 6. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.3 GLASS PRODUCTS, GENERAL

- A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.
1. GANA Publications: "Laminated Glazing Reference Manual" and "Glazing Manual."
 2. AAMA Publications: AAMA GD5G-1, "Glass Design for Sloped Glazing," and AAMA TIR A7, "Sloped Glazing Guidelines."
 3. IGMA Publication for Sloped Glazing: IGMA TB-3001, "Guidelines for Sloped Glazing."
 4. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."

- B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC the SGCC or another certification agency acceptable to authorities having jurisdiction or manufacturer. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.
- C. Insulating-Glass Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of IGCC.
- D. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than the thickness indicated.
 - 1. Minimum Glass Thickness for Exterior Lites: 6 mm Insert thickness designation.
 - 2. Thickness of Tinted Glass: Provide same thickness for each tint color indicated throughout Project.
- E. Strength: Where annealed float glass is indicated, provide annealed float glass, heat-strengthened float glass, or fully tempered float glass[**as needed to comply with "Performance Requirements" Article**]. Where heat-strengthened float glass is indicated, provide heat-strengthened float glass or fully tempered float glass[**as needed to comply with "Performance Requirements" Article**]. Where fully tempered float glass is indicated, provide fully tempered float glass.
- F. Low-E Coatings: For glazing requiring low-e coatings, comply with the following.
 - 1. Provide a minimum of 95 percent edge deletion of low-e coating around the entire perimeter of the unit to ensure proper seal in insulated unit.
 - 2. Utilize coated glass produced using continuous in-line color measurement via spectrophotometer inspection device.
 - 3. Tolerance for color variation to be no greater than a total range of 4.5 delta E for color incident and at angle, based on measurement protocol described in ASTM C1376.
 - 4. Transmitted and reflected color for all coated glass shall be consistent and fall on the same side of the neutral axis of the color spectrum as defined in ASTM D2244.

2.4 GLASS PRODUCTS

- A. Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.
 - 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
 - 2. Heat Soak Testing: For all fully tempered glass, provide heat soak testing conforming to EN14179 which includes a 2 hour dwell at 290 deg C, +/- 10 deg C.
- B. Heat-Strengthened Float Glass: ASTM C1048, Kind HS (heat strengthened), Type I, Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.
 - 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
 - 2. For uncoated glass, comply with requirements for Condition A.
 - 3. For coated vision glass, comply with requirements for Condition C (other coated glass).
 - 4. Limit Kind HS surface compression to upper end of ASTM C 1048 range, 7,500 psi.
 - 5. Distortion Tolerances:

- a. Roller Wave: Maximum 0.003 inch (0.076 mm) from peak to valley within the main body of the sheet and maximum 0.008 inch (0.20 mm) within 10.5 inches of a leading or trailing edge.
 - b. Localized Warp: Maximum 0.03 inch (0.80 mm) over any 12 inch (305 mm) span, but limited to 0.31 inch (8.00 mm).
- C. Low-E / Reflective-Coated Vision Glass: ASTM C1376.
- D. Low-E / Reflective-Coated Ceramic Spandrel Glass: ASTM C1376, Kind CS, coated by **[pyrolytic process][vacuum deposition (sputter-coating) process]**, ASTM C1048, Condition B, Type I, Quality-Q3, and complying with other specified requirements.

2.5 LAMINATED GLASS

- A. Laminated Glass: ASTM C1172. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.
- 1. Construction: Laminate glass with polyvinyl butyral interlayer to comply with interlayer manufacturer's written instructions.
 - 2. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
 - 3. Interlayer Color: Clear unless otherwise indicated.
 - 4. Glass Edge Alignment Tolerances:
 - a. Concealed Laminated Glass Edge Offset:
 - 1) Edge length less than 80-inches: ± 0.04 inch.
 - 2) Edge length greater than 80-inches: ± 0.08 inch.
 - b. Exposed Laminated Glass Edge Offset: The edges of the laminated glass plies shall be flush and level ± 0.04 -inch.

2.6 INSULATING GLASS

- A. Insulating-Glass Units: Factory-assembled units consisting of sealed lites of glass separated by a dehydrated interspace, qualified in accordance with ASTM E2190.
- 1. Sealing System: Dual seal, with manufacturer's standard primary and secondary seal, and with soldered, welded, and/or bent spacer corner construction.
 - a. Units for Structural Sealant Glazing: Dual seal construction of a polyisobutylene primary seal and silicone secondary seal, and with soldered, welded, and/or bent spacer corner construction.
 - b. Secondary Seal: Continuous, free of skips and voids.
 - 2. Perimeter Spacer: Manufacturer's standard spacer material and construction.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Technoform Glass Insulation NA, Inc.
 - 2) Thermix; a brand of Ensinger USA.
 - 3. Desiccant: Molecular sieve or silica gel, or a blend of both.
 - 4. Units which will be shipped through or glazed at altitudes of 5000 feet (1520 meters) or more above sea level, fabricated with breather or capillary tubes, to permit air space pressure equalization. Provide same warranty as for non-breather or capillary tube units. Pinch tubes during glazing if required by glass manufacturer.

5. Flatness Tolerance: Manufacturer units so that maximum out-of-plane concavity/convexity, at center of each lite, does not exceed the following when ambient temperature is 70 degrees Fahrenheit and glass surface temperature is within +/- 5 degrees Fahrenheit of ambient temperature. Measure flatness with units installed in vertical position.
 - a. Units 20 square feet and longer in area: + / - 1/16-inch maximum.
 - b. Units smaller than 20 square feet: + / - 1/32-inch maximum.
 - c. If units are manufactured at geodetic elevation higher or lower than that of the Project, take measures to assure that flatness tolerance are met. If filling or deflating is used at time of manufacture to compensate for elevation difference, it shall be done after full curing of glass edge seals.

2.7 GLAZING GASKETS

- A. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from **[one of]** the following:
 1. Neoprene complying with ASTM C 864.
 2. EPDM complying with ASTM C 864.
 3. Silicone complying with ASTM C 1115.
 4. Thermoplastic polyolefin rubber complying with ASTM C 1115.
 5. Compression wedge for dry glazing system: of shape and size to compress the exterior compression gasket a minimum of 25 percent, and as recommended by glazing and sealing systems manufacturer.
 6. Provide gaskets that are compatible with glazing sealants and will provide for silicone adhesion.
- B. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned **[neoprene]** **[EPDM]** **[silicone]** **[or]** **[thermoplastic polyolefin rubber]** gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.
 1. Bed gasket for wet glazing system: continuous with pressure sensitive adhesive 1 side, designed to be compressed 25-40 percent in the opening.
 2. Compression gasket for dry glazing system: shape as required to be compressed in place a minimum of 25 percent and of one-piece construction with factory-assembled frames with injection-molded, vulcanized corners; produced oversize in opening dimension, as determined by measurements, to insure compression at corners but within limits so that compression does not create a "pucker".
 3. Channel gasket: continuous channel of shape and dimensions for application in the opening with specified glazing.
 4. Provide gaskets that are compatible with glazing sealants and will provide for silicone adhesion.

2.8 GLAZING SEALANTS

- A. General:
 1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
 2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.

3. Sealant shall have a VOC content of 250 g/L or less.
4. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
5. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range.

B. Glazing Sealant:

1. Neutral-curing silicone glazing sealant complying with ASTM C920, Type S, Grade NS, Class 100/50, Use NT.
 - a. Manufacturers: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Dow Corning Corporation; 790.
 - 2) GE Construction Sealants; Momentive Performance Materials Inc.; SilPruf LM SCS2700.
 - 3) Tremco Incorporated; Spectrem 1.
 - b. Applications: **<Describe types of glazing applications where this sealant is required>.**
2. See Section 08 4423 "Structural-Sealant-Glazed Curtain Walls for information on structural sealant.

2.9 GLAZING TAPES

- A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:
1. AAMA 804.3 tape, where indicated.
 2. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
 3. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.
- B. For openings up to 75 united inches (1900 united mm), use unshimmed tape. For openings over 75 united inches (1900 united mm), use pre-shimmed tape.

2.10 MISCELLANEOUS GLAZING MATERIALS

- A. General: Provide products of material, size, and shape complying with referenced glazing standard, with requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
- B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.
- C. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

1. Each block shall be properly sized for load, as wide or wider than glazing, no less than 4 inches (100 mm) long; profile to permit friction fit, dart insertion into metal chair, or pressure sensitive adhesive one side to fix block in glazing opening.
 - D. Spacers: Elastomeric blocks or continuous extrusions of 40 to 60 Shore "A" durometer hardness to maintain glass lites in place for installation indicated.
 1. Profile to permit friction fit, dart insertion or pressure sensitive adhesive one side to fix shim or spacer in location.
 - E. Edge Blocks: Elastomeric material of 40 to 60 Shore "A" durometer hardness to limit glass lateral movement (side walking).
 1. Each block shall be a minimum of 4 inches (100 mm) long, as wide as glazing, placed in the vertical glazing channel, and sized to allow a nominal 1/8-inch (3-mm) clearance between glass edge and installed block; profile to permit friction fit or pressure sensitive adhesive one side to fix block in glazing opening.
 - F. Cylindrical Glazing Sealant Backing: ASTM C1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.
 - G. Open Cell Filter: Reticulated flexible polyester urethane foam having 20 pores per inch, sized at least 1 inch (25 mm) larger in dimension than weephole, of cross section to provide 15 to 25 percent compression for friction fit and as manufactured by Foam Division, Scott Paper Co.; H-O Products Corp. or approved comparable product.
 - H. Bond Breaker : Heavy duty, 11-mil (0.28-mm) minimum thickness, colored, polyethylene or teflon, self-adhesive bond breaker of type recommended by sealant manufacturer and suitable for conditions of usage. Liquid bond breaker is not permitted.
- 2.11 FABRICATION OF GLAZING UNITS
- A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
 1. Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.
 - a. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
 - B. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites to produce square edges with slight chamfers at junctions of edges and faces.
 - C. Grind smooth and polish exposed glass edges[**and corners**].
 - D. Speaking Holes: 4 inches (100 mm) in diameter, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:
 - 1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.
 - 2. Presence and functioning of weep systems.
 - 3. Minimum required face and edge clearances.
 - 4. Effective sealing between joints of glass-framing members.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.
- B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that leave visible marks in the completed Work.

3.3 GLAZING, GENERAL

- A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.
 - 1. Ensure approved Quality Assurance Program is implemented.
- B. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances
- C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.
- D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
- E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
 - 1. Locate one quarter of glass width from each corner, but with block edge nearest corner no closer than 6 inches (150 mm) from corner, unless otherwise specified or required by glass manufacturer.
 - 2. Insulating glass used in sloped glazing shall have both panes supported by setting blocks.

- F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.
 - G. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).
 - 1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.
 - 2. Provide 1/8-inch (3-mm) minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.
 - H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.
 - I. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.
 - J. Set glass lites with proper orientation so that coatings face exterior or interior as specified.
 - K. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.
 - L. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.
 - M. Where butted glass without mullions is indicated, seal open joints with silicone sealant in accordance with sealant and glass manufacturer's written instructions. Set glass so that joint is plumb and glass edges are aligned to provide for a uniform joint width of 3/8 inch maximum. Mask edges of glass to confine sealant to joints and to avoid contact with either face of glass. Use primer where required. Neatly tool joints to slightly concave surface using recommended tooling agent. Remove masking from glass and clean glass surfaces completely free of sealant material.
- 3.4 TAPE GLAZING
- A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.
 - B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
 - C. Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.
 - D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
 - E. Do not remove release paper from tape until right before each glazing unit is installed.

- F. Apply heel bead of elastomeric sealant.
- G. Center glass lites in openings on setting blocks, and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.
- H. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.5 GASKET GLAZING (DRY)

- A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
- B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.
- C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
- D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks, and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.
- E. Install gaskets so they protrude past face of glazing stops.

3.6 SEALANT GLAZING (WET)

- A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or backings in place and in position to control location and depth of installed sealant for required sealant performance.
- B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.
- C. Tool exposed surfaces of sealants to provide a smooth surface and on exterior applications provide a wash away from glass.

3.7 STRUCTURAL SEALANT GLAZING

- A. Install continuous spacers between glass lites and glazing channels to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
- B. Perform no structural sealant glazing prior to written certification of adhesion and compatibility test results, review and written approval of glazing details by glass and sealant manufacturers, and acceptance of written quality assurance program.
- C. Install glass in metal windows or framing with continuous spacer installed between glass and window or frame, setting blocks properly sized and located and structural sealant installed in properly sized and located cavity formed by glass, spacer and window or frame.
- D. Provide installation that maintains glass face clearances and prevents sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or backings in place and in position to control location and depth of installed sealant for required sealant performance.
- E. Perform installation procedures per written sealant and glass manufacturers' requirements and written quality assurance program.
- F. Force sealants into glazing channels to eliminate voids and to ensure complete wetting and bond of sealant to glass and channel surfaces.
- G. Tool exposed surfaces of sealants to provide a smooth surface and on exterior applications provide a wash away from glass.
- H. Do not allow sealant to bleed into the interface between the glass and glazing spacer.
- I. Structural sealant work shall be shop-glazed.

3.8 CLEANING AND PROTECTION

- A. Immediately after installation remove nonpermanent labels and clean surfaces.
- B. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.
- C. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
 - 1. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.

- D. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.
- E. Remove and replace glass that is damaged during construction period.
- F. Wash glass on both exposed surfaces not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

3.9 LAMINATED GLASS SCHEDULE: IGL-1

3.10 INSULATING GLASS SCHEDULE:

END OF SECTION

FOR REFERENCE ONLY

SECTION 08 8813 - GLASS VIEWING PANELS**PART ONE – GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Provide all glass viewing panels, as shown on the Drawings, as specified herein, and as needed for a complete and proper installation.
 2. Works Includes:
 - a) Panel at Viewing
 - b) Glazing engineering of panel composition
 - c) Structural support for the panels above
 3. Coordination:
 - a) Panel Rebates: coordinate the work of this section with the work of Section 03 30 00 Cast-in-Place Concrete or 03 37 13 Artificial Rockwork.
 - b) Structural Support: coordinate the work of this section with the work of Section 03 30 00 Cast-in-Place Concrete or 03 37 13 Artificial Rockwork.
- B. Related Sections:
- 03 30 00 Cast-in-Place Concrete
 - 03 37 13 Artificial Rockwork
 - 05 50 00 Metal Fabrications

1.2 ADMINISTRATIVE REQUIREMENTS:

- A. Coordination:
- Coordinate components of the work of this Section with work performed by other Sections in sufficient time to allow for other components of the work to incorporate requirements of this Section without causing delay to the work, including the following:
- B. Pre-Installation Conference:
- a) Conduct a pre-installation conference with the consultant, general contractor, the manufacturer's technical advisor(s), and the Installer of the glass viewing panels and representatives of the trades who will be conducting work in the immediate areas during the installation.
 - b) Coordinate installation procedures and specifically inform the other trades working in the area of the protection measures required during and after the installation of the viewing panels.

1.3 DEFINITIONS

- A. Manufacturers of Glass Products:
- Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.
- B. Glass Thicknesses:
- Indicated by thickness designations in inches, and millimeters according to ASTM C 1036.
- C. Deterioration of Laminated Glass:
- Defects are those developed from normal use that are attributed to the manufacturing process and not to causes such as glass breakage and practices for maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, fogging, and blemishes exceeding those allowed by referenced laminated-glass standard.

D. Deterioration of Anti-Reflective Coating:

Defects are those developed from normal use that are attributed to the manufacturing process and not to causes such as glass breakage and practices for maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include separation of the coating materially obstructing vision through glass.

1.4 SYSTEM DESCRIPTION:**A. Delegated Design:**

1. The work of this section requires professional design services or certifications by a design professional employed by the fabricator, and who is not the Consultant.
2. Complete the design of the viewing panels and rebates.
3. Maintain the general design concept shown.
4. Do not change member sizes or alter profiles and alignment, except as outlined in the design processes of this section.

B. Structural Systems Design:

1. Structural Engineering:
 - a) Provide the structural engineering design for viewing panels and rebates.
 - b) Drawings and Calculations:
Provide complete design, calculations, and drawings, prepared and signed in accordance with pertinent provisions of division one of these Specifications.
 - c) Licensed Engineer:
Design drawings will be prepared, approved, signed and sealed by a licensed professional engineer.
2. Design:
 - a) Panels:
Design panels to withstand the design pressures without failure of the viewing panel, failure of the waterproof seal between panel and structure, deterioration of the glazing materials, or other defects in the work.
 - b) Glazing Deflection:
Limit deflections to flexure limit of glazing, providing for full recovery of glazing.
 - c) Varying Conditions:
Design panels for the maximum thermal variation of the project installation, and wind and animal impact loads.
 - d) Rebate Design:
Design the proper profile and depth for the rebate that will receive the viewing panels.
 - e) Safety Factor:
 - 1) Glass thickness designations indicated in the documents are minimums and are for detailing only.
 - 2) Provide actual glass thicknesses by analyzing project loads and in-service conditions.
 - 3) Design to a theoretic risk of breakage equal to 1.0% or less.
 - f) Waterproofing:
 - 1) Provide design of connection and waterproof seal of the pool vessel water proofing system to the viewing panel.
 - 2) Overlap the waterproofing specified in section 03 37 13 Artificial Rockwork, with the panel rebate and sealant to provide assurance against water leakage.
3. General Design Loads:
Design all elements for the following loads:

- a) Dead loads
- b) Live loads due to animals and keeper staff
- c) Wind loads where applicable
- 4. Design Criteria:
 - a) Maximum panel height is as shown on drawings.
 - b) Minimum panel width is as shown on the drawings.
 - c) Maximum height of water against the panel is: N/A
 - d) Panels are supported as shown on the details
 - e) Temperature Range: Washington D.C., 95°F to 0°F
- 5. Animal Load Design Criteria:
 - a) Jaguar maximum mass equals 70lbs
 - b) Impact occurs 3-ft above bottom of panel.
 - c) Impact occurs over 1 sq foot (0.00108 sq cm).
- C. Performance Requirements:
 - 1. General:
 - a) Corrosion:
All materials must be corrosion resistant in the pool vessel operating environment.
 - b) Materials specified herein are intended to establish the standards of quality required for the Work of this Section.
 - c) All materials and/or completed fabrications must have a twenty (20) year structural service life.
 - d) Glazing Deflection:
Limit deflections to flexure limit of glazing, providing for full recovery of glazing.
- D. Approvals and Permits:
 - 1. General:
Secure the approval of governmental agencies having jurisdiction prior to submitting for the Consultant's approval.
 - 2. Building Permits:
Obtain all required permits and approvals for proposed systems.

1.5 SUBMITTALS

- A. General:
 - 1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
 - 2. Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit the following:
- B. Design Drawings:
 - 1. Delegated Design:
 - a) Submit complete drawings accurately showing proposed all of the fabrications described in this section, prepared in accordance with the following provisions:
 - b) Verify materials selection and sizes.
 - c) Verify fabrication and connection details for the fabrications or suggest alternative connection details.
 - d) Design system utilizing the system components specified in Part 2 of this specification.
 - e) Revise drawings as required by the Owner and resubmit.
 - 2. Delegated Design Submittals:

- a) Provide all submittals described in Section 01 33 50 as required for the work of this section.
- 3. Design Notes and Calculations:
 - a) When requested by Consultant, submit design notes and calculations, signed and sealed by the Professional Engineer.
- C. Manufacturer's Product Data:
 - 1. Complete materials list showing all items proposed to be furnished and installed under this section.
 - 2. Manufacturers technical literature describing the polymer, sealants, and other material proposed for this application.
 - 3. Names of manufacturer's technical advisors.
 - 4. Manufacturer's recommended installation procedures which, when accepted by the Consultant, will become the basis for accepting or rejecting actual installation procedures used on the Work.
- D. Construction Narrative and Schedule:
 - 1. Provide detailed narrative plan describing installation process, equipment requirements, manpower requirements, physical and environmental conditions required during installation and curing period, plan for protection and testing of installation, and all other related process required to complete this section
 - 2. Provide schedule of viewing panel submittals, delivery, and installation. Interface with all corresponding activities of the construction schedule for the entire project.
 - 3. Carefully schedule the arrival, installation, curing, and testing of the panel by tank filling, draining, and final filling so as not to delay the project in any manner.
 - 4. Allow adequate time for repair of leaks and the refilling and retesting of the tank.
 - 5. Adjust schedule as required by Consultant and general contractor to meet the requirements of the entire project.
- E. Shop Drawings and Design Calculations:
 - 1. Provide design engineering calculations specifying the viewing panel thickness, proposed glazing systems, and the interface of the viewing panel with the supporting structure and rebates.
 - 2. Provide Shop Drawings and details completely showing the fabrication, installation, and anchorage of the viewing panel, and the interface of the work of this section with the work of adjacent trades.
- F. Shop and Field Measurements:
 - 1. Due to the fast track construction schedule and the lead-time for manufacturing of the viewing panels, field measurements of the viewing panel openings may not be available at the time of panel manufacture.
 - 2. If the viewing panels must be fabricated prior to completion of the viewing panel rebates. submit actual shop measurements of the fabricated viewing panels to the General Contractor. The General Contractor shall then be responsible for constructing the viewing panel opening to the shop measurements. These measurements shall include but not be limited to deviation from prescribed plumbness, squareness, level, size, and thickness.
 - 3. If the viewing panel rebates are completed prior to the manufacturing of viewing panel, the General Contractor shall provide the Viewing Panel Manufacturer with field measurements of the concrete openings prior to fabrication of the panels.
- G. Samples:

Accompanying the above product data, submit:

 - 1. Viewing Panel:

Provide one sample of viewing panel 600mm by 600mm (24-inches by 24-inches) by the designed thickness for each viewing panel condition demonstrating clarity, finish, visual color and surface finish as delivered.

2. Sealant:

Samples, at least 300mm (12-inches) long, of each type of sealant proposed to be used, installed between samples of the material to be glazed, fully cured.

1.6 QUALITY ASSURANCE

A. Standards:

1. Regulatory Requirements:

- a) International Building Code, latest edition, as modified by the local jurisdiction.
- b) Relevant Building Code for the jurisdiction in which the project is being constructed.
- c) Comply with all current applicable requirements of state and local Fire Marshall.
- d) ANSI / NFPA 101 Life Safety Code, current edition
- e) ANSI / NFPA 150 Animal Standard on Fire & Life Safety in Animal Housing Facilities, current edition

2. Industry Standards:

- a) GANA, Glazing Manual
 - b) GANA, Laminated Glazing Reference Manual
 - c) Flat Glass Marketing Association "Glazing Sealing Systems Manual",
 - d) Flat Glass Marketing Association "Glazing Manual"
 - e) ULI (Underwriters' Laboratories, Inc.) Building Materials List, for labeled openings.
3. ISO 12453-6, Glass in Buildings – Laminated Glass and Laminated Safety Glass (defines allowable visual defects)

B. Manufacturer's Qualifications:

Manufacturer of the laminated glass viewing panels shall provide evidence of having experience, for the last five (5) years, in the manufacture, shipping and installation of laminated glass viewing panels of similar size and configuration to those required by this project.

C. Installer's Qualifications:

1. Manufacturer shall provide evidence that the installation technical advisors to be used for this project have experience, for the last five (5) years, in the installation of laminated glass viewing panels of similar size and configuration to those required by this project.
2. Provide a minimum of two (2) manufacturer's technical advisors to be present at the time of panel installation and sealant application.
3. Use skilled glaziers and laborers who are trained and experienced in laminated glass panel glazing and practices required for underwater pool vessel installations, and who are familiar with the specified requirements and the methods needed for proper performance of the Work of this Section.

D. Concrete Opening Certification:

The viewing panel Contractor shall inspect and certify in writing the acceptance of the concrete sill, jamb and header conditions at each location as suitable for installation of laminated glass viewing panels.

1.7 PRODUCT HANDLING

A. General:

Comply with the pertinent provisions of Sections of 01 60 00 Product Requirements.

B. Protection

1. Use all means necessary to protect the materials of this Section before, during, and after installation and to protect the Work and materials of all other trades.
 2. During storage and handling of glass, provide cushions at edges to prevent impact damage.
- C. Packing and Shipping:
1. The manufacturer shall design special packing and shipping procedures to ensure that the viewing panels are not damaged during shipping.
 2. Protect the viewing panel with protective plywood and an appropriate separator sheet that will remain in place through-out shipping and installation. This will require that the edges of the protective crate be removed just prior to the installation of the panel into its opening.
- D. Acceptance at Site:
1. The Consultant and Owner will inspect the viewing panel upon delivery to the site for obvious damage to the protective packaging.
 2. Remove and replace damaged items.
- E. Storage and protection:
1. Store protected viewing panels in accordance with the manufacturer's requirements.
 2. Make every effort to protect the viewing panels prior to and following installation until final acceptance.
- F. Replacements:
1. Panels Damaged by the Viewing Panel Contractor:
 - a) Viewing panels broken or damaged during the course of the Work by viewing panel Contractor's workers or due to manufacturing defects or inadequate protection are the responsibility of the viewing panel Contractor.
 - b) In the event of such damage, immediately make all repairs and replacements necessary.
 2. Panels Damaged by Other Causes:
 - a) Costs of replacing or repairing glazing broken or damaged by other Contractors during the Work are the responsibility of the Contractor causing the damage.
 - b) Costs of replacing or repairing viewing panels broken or damaged by natural causes, accidents, or vandalism are the responsibility of the General Contractor.
 - c) In the event of such damage, the viewing panel Contractor will repair or remove and replace the viewing panels that are broken or damaged.

1.8 WARRANTY

- A. Manufacturer's Special Warranty on Laminated Glass:
1. Manufacturer's standard form made out to Owner and signed by laminated-glass manufacturer agreeing to replace laminated-glass units that deteriorate as defined in "Definitions" Article, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
 2. Warranty Period:
10 years from date of Substantial Completion.
- B. Installer's Special Warranty on installations subject to partial or full water immersion:
1. Installer shall warrant that the installation shall be free of leaks and agreeing to remove and reinstall the glass and glazing materials as required in order to make it water tight.
 2. Warranty Period:
 3. 5 years from date of Substantial Completion.
- C. Manufacturer's Special Warranty on Anti-Reflective Coating:

1. Manufacturer's standard form made out to Owner and signed by laminated-glass manufacturer agreeing to replace laminated-glass units with anti-reflective coating that deteriorate as defined in "Definitions" Article, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.
2. Warranty Period:
10 years from date of Substantial Completion.

PART TWO - PRODUCTS

2.1 GLAZING PANEL:

A. General:

See Delegated Design requirements

1. Laminated Glass Interlayers:
 - a) Polyvinyl butryl (pvb), polycarbonate, or acrylic interlayers, thickness as recommended by the glass manufacturer and system design.
 - b) Ionoplast interlayers, thickness as recommended by the glass manufacturer and the system design.
2. Low-Iron Clear Float Glass:
As produced by the referenced manufacturer's products below.
3. Non-Reflective Coating:
Provide proprietary non-reflective coatings as specified by the individual manufacturer's noted below.

B. Acceptable Products and Manufacturers:

Low iron and non-reflective

1. Pilkington 'Optiview'
2. Schott, 'Amiran', Water-white
3. PPG SOLARPHIRE(R) Anti-Reflective Glass
4. St Gobains SGG Vision-Lite Anti-Reflective Glass

C. Fabrication:

1. Fabricate glass as shown on the Drawings.
2. Grind and polish edges as required for butt glazing at the angles shown on the Drawings.

2.2 GLAZING ACCESSORIES

A. General:

1. Provide all glazing accessories required to supplement those accessories which accompany the items to be glazed, and as needed to provide a complete installation, including glazing points, clips, shims, angles, beads, setting blocks, and spacer strips.
2. Use only stainless steel or FRP accessories.

B. FRP Mounting Clips, angles, plates, and rebate embeds:

1. Designed and supplied by the Glazing Panel Manufacturer or their approved vendor.

C. Back-up Material:

Polyethylene foam rod of non-adhering type recommended by sealant manufacturer.

D. Silicone Sealant:

1. As recommended by viewing panel manufacturer and which has been successfully used at other similar installations.
2. Provide compatible primer where required.
3. Approved Sealant Products:

Subject to compliance with requirements, products that may be incorporated in the work include, but are not limited to, the following:

- a) Shinetsue, 70-6x, 2-part silicone sealant
 - b) Toray, SH 792, 2-part silicone sealant
 - c) PRC, PR-383, 2-part polysulfide sealant
 - d) Dow Corning, 999, 1-part silicone sealant
 - e) Dow Corning, 795, 1-part silicone sealant
 4. Dow Corning No. 781, clear silicone sealant for sealant in frames,
 5. Dow Corning No. 732, silicone sealant for butt joints, color black.
 6. Apply sealant leaving no voids.
- E. Neoprene Bearing Pads:
1. Glass Panels:
 - a) Shore Hardness 40-50 with continuous corners.
 - b) At corner vulcanize or glue joints to 50% of native strength minimum.
 - c) Glue pads to substrate surfaces to prevent slippage.
- F. Neoprene Setting Blocks:
1. Glass Panels:
 - a) Shore Hardness 70-90,
 - b) Size as recommended by installer.
 - c) Two at each sill at quarter points.
- G. Sealant Protection from Animals:
- Provide custom stainless-steel joint protection at all sealant joints which will be exposed to animals in the completed construction.
1. Embed stainless steel strip firmly in sealant and recess 3-4mm below the face of the glazing panels.
- H. Edge Protection:
- Provide stainless steel edge protection or Manufacturer's standard weather protection at all laminated glass edges exposed to weather or moisture.

PART THREE - EXECUTION

3.1 INSPECTION

A. General:

Examine the areas and conditions under which Work of this Section will be performed. Correct conditions detrimental to the proper and timely completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

B. Responsibilities:

1. Insure that pool vessel and water-proofing are complete prior to beginning the work of this section. Leakage at the viewing panel and viewing panel rebate are the responsibility of the viewing panel Contractor.
2. Leakage at the waterproofed pool vessel is the responsibility of the General Contractor.

3.2 INSTALLATION

A. Inspection:

Inspect each piece of glass immediately prior to start of installation.

1. Do not install items which are improperly sized, have damaged edges, or are scratched, abraded, or damaged in any other manner.
2. Do not remove labels from glass until so directed by the Consultant.

3. Install glass so distortion waves, if present, run in the horizontal direction.
- B. Cleaning Rebates and Glazing Channels:
1. Surfaces must be clean, free of old coatings and should be either acid etched or sand blasted.
 2. All cracks and holes in concrete are to be epoxy injected and patched with epoxy waterproof sealant and sanded smooth.
 3. Install epoxy injection and waterproof sealant according to viewing panel manufacturer's instructions.
 4. Clean the rabbet area to be sealed with epoxy waterproofing with a cloth soaked with toluene.
 5. Clean area to be sealed on the viewing panel with a cloth soaked with methyl-alcohol.
 6. Cut the polyethylene foam sheet backer into appropriate sizes and insert it into the joint slot.
 7. Apply masking tape on both sides of all joints.
 8. Clean the sealing area again on both the epoxy waterproofing and the viewing panel.
- C. Primers:
1. Apply primers to joint surfaces required for adhesion of sealants as determined by preconstruction sealant-substrate testing.
 2. Apply primers on clean, oil-free surfaces and never touch the treated area.
 3. Carefully apply the primers so that there will be no application to adjacent surfaces.
 4. Air-dry the treated primers for not less than 30 minutes or more than 36 minutes.
 5. The primers are flammable. Keep them away from heat, sparks and flame. Use them only in well-ventilated area. (No smoking allowed.)
 6. Take care not to touch the concrete and acrylic viewing panel surfaces after they have been cleaned in accordance with these specifications.
- D. Setting Blocks and Spacers:
1. Install setting blocks of proper size, locate one quarter of panel width from each corner, but no closer than 150mm (6-inches), unless otherwise required at intermediate points specified by acrylic viewing panel Manufacturer.
 2. Set blocks in thin course of sealant which is acceptable for heel bead use.
 3. Provide spacers of correct size and spacing to preserve required face clearances, and use thickness equal to sealant width.
 4. Provide edge blocking to comply with requirements of referenced glazing standard, except where otherwise required by acrylic viewing panel Manufacturer.
- E. Bond Breakers:
- Provide compressible filler rods or equivalent back-up materials and bond breakers, as recommended by sealant and viewing panel manufacturer, to prevent sealant from adhering to joints back surface and to control depth of sealant for optimum performance.
- F. Butt Joint Glazing
1. Field verify dimensions for installation of glazing with butt joints prior to cutting the glass into the shapes as shown on the Drawings.
 2. Fabricate glass as required for each installation.
 3. Unless otherwise approved or shown on the Drawings, install with uniform 1/8" gap between glass sheets at butt joints
 4. Finish joints with silicone sealant per sealant manufacturer's recommendations.
 5. Install with clear silicone sealant at all butt joints except for glass panels at aquatic exhibits.

6. Install with black silicone sealant at aquatic exhibits.
7. Install clear sealant at all butt joints between glass and Artificial Rockwork not in contact with pools.

3.3 PROTECTION AND CLEANING

A. Viewing Panel Protection:

1. Protect viewing panels from damage immediately upon installation by use of temporary partitions and the specified protection attached to framing held away from glazing.
2. Do not apply markers to surfaces of view window. Remove non-permanent labels and clean surfaces.

B. Contamination by Foreign Substances:

1. Protect glazing from contact with contaminating substances resulting from construction.
2. If contaminating substances do come into contact with view window, remove immediately by the method recommended by viewing panel manufacturer.

C. Final Cleaning and Polishing:

1. Clean viewing panel on both faces not more than 12-hours prior to date scheduled for visual inspections intended to establish date of substantial completion in each area of project.
2. Using cleaning methods recommended by the viewing panel manufacturer.

END OF SECTION

SECTION 08 8853 - SECURITY GLAZING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes:
 - 1. Laminated-glass security glazing
 - 2. Insulating security glazing.

1.2 DEFINITIONS

- A. Glazing Manufacturers: Firms that produce primary glass, monolithic plastic glazing, or fabricated security glazing, as defined in referenced glazing publications.
- B. Interspace: Space between lites of air-gap security glazing or insulating security glazing.

1.3 COORDINATION

- A. Coordinate glazing channel dimensions to provide necessary bite on security glazing, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - 2. Review temporary protection requirements for security glazing during and after installation.

1.5 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required **[Product Data submittal]** **and** **[Samples submittal]**. Ensure compliance with requirements included in **[Section 01 3300 "Submittal Procedures"]** **[Section 08 0413 "Common Submittal Requirements for Openings"]**.
- B. Product Data: For each type of product.
- C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of **[glass tint]** **[glass coating]** **[colored interlayer]** **[sealant]** **and** **[colored spacer]**.
- D. Samples for Verification:
 - 1. Glazing: Actual sample of finished products for each type of security glazing.
 - a. Size: **[Manufacturers' standard size]** **<Insert size>**.
 - 2. Glazing Accessories: Actual sample of **[sealants]** **and** **[colored spacers]**. **[Install sealant Samples between two strips of material representative in color of the adjoining framing system.]**
 - 3. Size: **[Manufacturers' standard size]** **<Insert size>**.

- E. Security Glazing Schedule: List security glazing types and thicknesses for each size opening and location. Use same designations indicated on Drawings. Indicate coordinated dimensions of security glazing and construction that receives security glazing, including clearances and glazing channel dimensions.
- F. Sustainable Design Submittals:
 - 1. Product Data: For sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

1.6 INFORMATIONAL SUBMITTALS

- A. Test and Evaluation Reports:
 - 1. Product Test Reports:
 - a. For each type of security glazing, for tests performed by **[qualified testing agency][manufacturer and witnessed by a qualified testing agency]**.
 - b. For each type of glazing sealant, for tests performed by a qualified testing agency.
 - 1) Provide test reports based on testing current sealant formulations within previous 36-month period.
 - 2. Preconstruction Test Reports: For preconstruction adhesion and compatibility testing.
- B. Qualification Statements: For **[installers][manufacturers of insulating or air-gap security glazing with sputter-coated, low-e coatings][glazing testing agency][and][sealant testing agency]**.

1.7 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Manufacturers: For insulating or air-gap security glazing units with sputter-coated, low-e coatings, a qualified insulating glazing manufacturer who is approved **[and certified]** by coated-glass manufacturer.
 - 2. Installers: **[Fabricator of products][Entity that employs installers and supervisors who are trained and approved by manufacturer][Authorized representative who is trained and approved by manufacturer]**.
 - 3. Delegated Design Engineer: A professional engineer who is legally qualified to practice in **[state]<Insert jurisdiction>** where Project is located and who is experienced in providing engineering services of type indicated.
 - 4. Security Glazing Testing Agency: Subject to compliance with requirements, testing agency is one of the following:
 - a. Intertek.
 - b. Underwriters Laboratories, Inc.
 - c. Wiss, Janney, Elstner Associates, Inc.
 - d. **<Insert testing agency name>**.
 - 5. Sealant Testing Agency: An independent testing agency qualified in accordance with ASTM C1021 to conduct the testing indicated.

1.8 PRECONSTRUCTION TESTING

- A. Preconstruction Adhesion and Compatibility Testing: Test each security glazing type, tape sealant, gasket, glazing accessory, and glazing-framing member for adhesion to and compatibility with elastomeric glazing sealants.
1. Testing will not be required if data based on previous testing of current sealant products and glazing materials match those submitted.
 2. Use ASTM C1087 to determine whether priming and other specific joint-preparation techniques are required to obtain rapid, optimum adhesion of glazing sealants to security glazing, tape sealants, gaskets, and glazing channel substrates.
 3. Test no fewer than **[eight]<Insert number>** Samples of each type of material, including joint substrates, shims, sealant backings, secondary seals, and miscellaneous materials.
 4. Schedule sufficient time for testing and analyzing results to prevent delaying the Work.
 5. For materials failing tests, submit sealant manufacturer's written instructions for corrective measures, including the use of specially formulated primers.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect security glazing and glazing materials in accordance with manufacturer's written instructions. Prevent damage from condensation, temperature changes, direct exposure to sun, or other causes.
- B. Comply with insulating security glazing and with air-gap security glazing manufacturers' written recommendations for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.10 FIELD CONDITIONS

- A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.
1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or below 40 deg F (4.4 deg C).

1.11 WARRANTY

- A. Special Warranty, Coated Glass: Manufacturer agrees to replace coated glass that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects developed in coated glass from normal use that is not attributed to glass breakage or to maintaining and cleaning coated glass contrary to manufacturer's written instructions. Defects include peeling, cracking, and other indications of deterioration in coating.
 2. Warranty Period: **[10]<Insert number>** years from date of Substantial Completion.
- B. Special Warranty, Laminated-Glass Security Glazing: Manufacturer agrees to replace laminated-glass security glazing that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:

- a. Defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated-glass security glazing contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
 2. Warranty Period: [Five][10]<Insert number> years from date of Substantial Completion.
- C. Special Warranty, Monolithic Polycarbonate Security Glazing: Manufacturer agrees to replace monolithic polycarbonate security glazing that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects developed from normal use that are not attributed to maintaining and cleaning monolithic polycarbonate security glazing contrary to manufacturer's written instructions. Defects include yellowing and loss of light transmission.
 2. Warranty Period: [10]<Insert number> years from date of Substantial Completion.
- D. Special Warranty, Laminated-Polycarbonate Security Glazing: Manufacturer agrees to replace laminated-polycarbonate security glazing that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects developed from normal use that are not attributed to maintaining and cleaning laminated-polycarbonate security glazing contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glazing, blemishes exceeding those allowed by referenced standard, yellowing, and loss of light transmission.
 2. Warranty Period: [Five][10]<Insert number> years from date of Substantial Completion.
- E. Special Warranty, Glass-Clad Polycarbonate Security Glazing: Manufacturer agrees to replace glass-clad polycarbonate security glazing that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning glass-clad polycarbonate security glazing contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glazing, blemishes exceeding those allowed by referenced polycarbonate standard, yellowing, and loss of light transmission.
 2. Warranty Period: [Five][10]<Insert number> years from date of Substantial Completion.
- F. Special Warranty, Laminated-Glass and -Polycarbonate Security Glazing: Manufacturer agrees to replace laminated-glass and -polycarbonate security glazing that fails in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 2. Defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated-glass and -polycarbonate security glazing contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glazing, blemishes exceeding those allowed by referenced polycarbonate standard, yellowing, and loss of light transmission.

3. Warranty Period: **[Five][10]<Insert number>** years from date of Substantial Completion.
- G. Special Warranty, Insulating Security Glazing: Manufacturer agrees to replace insulating security glazing that fails in materials and workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects in individual lites developed from normal use or failure of hermetic seal under normal use. Defects in individual lites or failure of hermetic seal that is attributed to glass breakage or to maintaining and cleaning insulating security glazing contrary to manufacturer's written instructions are not included.
 - b. Defects in coated-glass lites include peeling, cracking, and other indications of deterioration in coating.
 - c. Defects in laminated-glass lites include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
 - d. Defects in glass-clad polycarbonate lites include edge separation, delamination materially obstructing vision through glazing, blemishes exceeding those allowed by referenced glass-clad polycarbonate standard, yellowing, and loss of light transmission.
 - e. Evidence of hermetic seal failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glazing.
 2. Warranty Period: **[Five][10]<Insert number>** years from date of Substantial Completion.
- H. Special Warranty, Air-Gap Security Glazing: Manufacturer agrees to replace air-gap security glazing that fails in materials and workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Defects in individual lites developed from normal use or failure of hermetic seal under normal use. Defects in individual lites or failure of hermetic seal that is attributed to glass breakage or to maintaining and cleaning air-gap security glazing contrary to manufacturer's written instructions are not included.
 - b. Defects in coated-glass lites include peeling, cracking, and other indications of deterioration in coating.
 - c. Defects in laminated-glass lites include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.
 - d. Defects in laminated-polycarbonate lites include edge separation, delamination materially obstructing vision through glazing, blemishes exceeding those allowed by referenced standard, yellowing, and loss of light transmission.
 - e. Evidence of hermetic seal failure is the obstruction of vision by dust, moisture, or film on interior surfaces of glazing.
 2. Warranty Period: **[Five][10]<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of security glazing from single source from single manufacturer.
 1. Obtain **[tinted][and][coated]** glass from single source from single manufacturer.

- B. Obtain glazing [sealants][and][gaskets] from single source from single manufacturer for each product and installation method.

2.2 PERFORMANCE REQUIREMENTS

- A. General:
 - 1. Installed security glazing will withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or breakage attributable to defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.
 - 2. Installed security glazing will withstand security-related loads and forces without damage to the glazing beyond that allowed by referenced standards.
- B. Structural Performance: Glazing will withstand the following design loads within limits and under conditions indicated.
 - 1. Design Procedure for Glass: ASTM E1300 and the IBC.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
- D. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- E. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

2.3 SECURITY GLAZING, GENERAL

- A. Glazing Publications: Comply with published recommendations of security glazing and glazing material manufacturers and organizations below unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.
 - 1. IGMA Publication for Insulating Glass: SIGMA TM-3000.
 - 2. NGA Publications: "Laminated Glazing Reference Manual" and "GANA Glazing Manual."
- B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the Safety Glazing Certification Council or another certification agency acceptable to authorities having jurisdiction or manufacturer. Label will indicate manufacturer's name, type of glazing, glass thickness, and safety glazing standard with which glazing complies.
- C. Insulating Glazing Certification Program: Permanently marked either on spacers or on at least one component lite of units with appropriate certification label of the Insulating Glass Certification Council.
- D. Thermal and Optical Performance Properties: Provide security glazing with performance properties specified, as indicated in manufacturer's published test data, based on construction products indicated and on procedures indicated below:
 - 1. U-Factors: Center-of-glazing values, in accordance with NFRC 100 and based on most current non-beta version of LBL's WINDOW computer program, expressed as Btu/sq. ft. x h x deg F (W/sq. m x K).

2. SHGC and Visible Transmittance: Center-of-glazing values, in accordance with NFRC 200 and based on most current non-beta version of LBL's WINDOW 7.7 computer program.
3. Visible Reflectance: Center-of-glazing values, in accordance with NFRC 300.

2.4 GLASS PRODUCTS

- A. Heat-Treated Float Glass: ASTM C1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.
 1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.
 2. For heat-strengthened float glass, comply with requirements for Kind HS.
 3. For fully tempered float glass, comply with requirements for Kind FT.
 4. For uncoated glass, comply with requirements for Condition A.
 5. For coated vision glass, comply with requirements for Condition C (other coated glass).

2.5 LAMINATED-GLASS SECURITY GLAZING (IGL-2)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Dlubak Specialty Glass Corporation.
 2. Global Security Glazing.
 3. Oldcastle BuildingEnvelope (OBE); CRH Americas.
 4. Standard Bent Glass Corp.
- B. Laminated-Glass Security Glazing: ASTM C1172. Two or more glass lites bonded with interlayer. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.
 1. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.
 2. Interlayer Color: Clear unless otherwise indicated.

2.6 INSULATING SECURITY GLAZING (EGL-1)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Dlubak Specialty Glass Corporation.
 2. Global Security Glazing.
 3. Viracon, Inc.
- B. Insulating Security Glazing: Factory-assembled units, consisting of sealed lites of glazing material indicated separated by a dehydrated interspace, qualified in accordance with ASTM E2190
 1. Sealing System: Dual seal, with manufacturer's standard primary and secondary sealants.
 2. Spacer: Manufacturer's standard spacer material and construction.
 3. Desiccant: Molecular sieve or silica gel, or blend of both.

2.7 GLAZING SEALANTS

- A. General:

1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they contact, including security glazing, seals of insulating security glazing and air-gap security glazing, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
2. Suitability: Comply with sealant and security glazing manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
3. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range of Industry colors.

B. Glazing Sealant:

1. Neutral-Curing Silicone Glazing Sealant, Class 100/50: Complying with ASTM C920, Type S, Grade NS, Use NT.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GE Construction Sealants; Momentive Performance Materials Inc.
 - 2) May National Associates, Inc.; a subsidiary of Sika Corporation.
 - 3) Pecora Corporation.
 - 4) Sika Corporation.
 - 5) The Dow Chemical Company.
 - 6) Tremco Incorporated.
 - b. Applications: **<Describe types of glazing applications where this sealant is required>.**

C. Security Sealant: Manufacturer's standard, nonsag, tamper-resistant sealant for joints with low movement complying with ASTM C920, Grade NS, Class 12.5 or 25, Use NT, and with a Shore A hardness of at least 45 when tested in accordance with ASTM C661.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Master Builders Solutions.
 - b. Pecora Corporation.

2.8 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and security glazing manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:

1. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.
2. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

- B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:
 - 1. AAMA 810.1, Type 1, for glazing applications in which tape acts as the primary sealant.
 - 2. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

2.9 MISCELLANEOUS GLAZING MATERIALS

- A. General: Provide products of material, size, and shape complying with referenced glazing standard, recommended in writing by manufacturers of security glazing and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.
- B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.
- C. Setting Blocks:
 - 1. EPDM with Shore A durometer hardness of 85, plus or minus 5.
 - 2. Type recommended in writing by sealant or glass manufacturer.
- D. Spacers:
 - 1. [Neoprene]<Insert type> blocks or continuous extrusions of hardness required by security glazing manufacturer to maintain security glazing lites in place for installation indicated.
 - 2. Type recommended in writing by sealant or security glazing manufacturer.
- E. Edge Blocks:
 - 1. EPDM with Shore A durometer hardness in accordance with manufacturer's written instructions.
 - 2. Type recommended in writing by sealant or security glazing manufacturer.
- F. Cylindrical Glazing Sealant Backing: ASTM C1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

2.10 FABRICATION OF SECURITY GLAZING

- A. Fabricate security glazing in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.
- B. Grind smooth and polish exposed security glazing edges and corners.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine framing for security glazing, with Installer present, for compliance with the following:
 - 1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.

2. Presence and functioning of weep system.
3. Minimum required face or edge clearances.
4. Minimum required bite.
5. Effective sealing between joints of framing members.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean glazing channels and other framing members receiving security glazing immediately before glazing. Remove coatings not firmly bonded to substrates.
- B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that will leave visible marks in the completed work.

3.3 GLAZING, GENERAL

- A. Comply with combined written instructions of manufacturers of security glazing, sealants, gaskets, and other glazing materials unless more stringent requirements are indicated, including those in referenced glazing publications.
- B. Protect edges of security glazing from damage during handling and installation. Remove damaged security glazing from Project site and legally dispose of it off Project site. Damaged security glazing includes units with edge or face damage or other imperfections that, when installed, could weaken security glazing and impair performance and appearance.
- C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.
- D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications unless otherwise required by glazing unit manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.
- E. Do not exceed edge pressures stipulated by security glazing manufacturers for installing lites.
- F. Provide spacers for security glazing lites where the length plus width is larger than 50 inches (1270 mm).
 1. Locate spacers directly opposite each other on both inside and outside faces of security glazing. Install correct size and spacing to preserve required face clearances unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with performance requirements.
 2. Provide 1/8-inch (3-mm) minimum bite of spacers on glazing lites and use thickness equal to sealant width. With glazing tape, use thickness of slightly less than final compressed thickness of tape.
- G. Provide edge blocking where indicated or needed to prevent security glazing from moving sideways in glazing channel, as recommended in writing by security glazing manufacturer and in accordance with requirements in referenced glazing publications.
- H. Set security glazing in each series with uniform pattern, draw, bow, and similar characteristics.

- I. Set coated security glazing with proper orientation so that coatings and films face exterior or interior as specified.
- J. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.
- K. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended in writing by gasket manufacturer.

3.4 TAPE GLAZING

- A. Position tapes on fixed stops so that, when compressed by security glazing, their exposed edges are flush with or protrude slightly above sightline of stops.
- B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.
- C. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.
- D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.
- E. Do not remove release paper from tape until just before each glazing unit is installed.
- F. Apply heel bead of elastomeric sealant.
- G. Center security glazing in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.
- H. Apply cap bead of elastomeric sealant over exposed edge of tape.

3.5 GASKET GLAZING (DRY)

- A. Cut compression gaskets to lengths recommended in writing by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.
- B. Insert soft compression gasket between glazing unit and frame or fixed stop, so it is securely in place with joints miter cut and bonded together at corners.
- C. Installation with Drive-in Wedge Gaskets: Center security glazing in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in security glazing. Seal gasket joints with sealant recommended in writing by gasket manufacturer.

- D. Installation with Pressure-Glazing Stops: Center security glazing in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in security glazing. Seal gasket joints with sealant recommended in writing by gasket manufacturer.
- E. Install gaskets so they protrude past face of glazing stops.

3.6 SEALANT GLAZING (WET)

- A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between security glazing and glazing stops to maintain face clearances and to prevent sealant from extruding into glazing channel and blocking weep systems. Secure spacers, or spacers and backings, in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.
- B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to security glazing and channel surfaces.
- C. Tool exposed surfaces of sealants to provide a substantial wash away from security glazing.

3.7 CLEANING AND PROTECTION

- A. Immediately after installation remove nonpermanent labels and clean surfaces.
- B. Protect security glazing from contact with contaminating substances resulting from construction operations, including weld splatter. Examine security glazing surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.
 - 1. If, despite such protection, contaminating substances do contact with security glazing, remove substances immediately as recommended in writing by security glazing manufacturer. Remove and replace security glazing that cannot be cleaned without damage.
- C. Wash security glazing on both exposed surfaces not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash security glazing as recommended in writing by security glazing manufacturer.

3.8 LAMINATED-GLASS SECURITY GLAZING SCHEDULE

3.9 INSULATING SECURITY GLAZING SCHEDULE

END OF SECTION

SECTION 08 9119 - FIXED LOUVERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Fixed extruded-aluminum louvers.

1.2 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).
- C. Vertical Louver: Louver with vertical blades (i.e., the axis of the blades are vertical).
- D. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
- E. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing in accordance with AMCA 500-L.
- F. Windborne-Debris-Impact-Resistant Louver: Louver that provides specified windborne-debris-impact resistance, as determined by testing in accordance with AMCA 540.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Health Product Declaration: For each product.
 - 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
 - 1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
 - 2. Show mullion profiles and locations.
- D. Samples: For each type of metal finish required.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

3. AWS D1.6/D1.6M, "Structural Welding Code - Stainless Steel."

B. Provide the following upon request:

1. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

1.5 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.6 WARRANTY

A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
2. Warranty Period: **[Five]** **[10]** **[20]** **<Insert number>** years from date of Substantial Completion.

B. Special Finish Warranty, Anodized Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of anodized finishes within specified warranty period.

1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, peeling, or chipping.
2. Warranty Period: **[Five]** **[10]** **<Insert number>** years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain fixed[**and operable**] louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures are considered to act normal to the face of the building.
1. Wind Loads:
 - a. Determine loads based on pressures as indicated on Drawings.
 - b. Determine loads based on a uniform pressure of [20 lbf/sq. ft. (957 Pa)] [30 lbf/sq. ft. (1436 Pa)] **<Insert value>**, acting inward or outward.
 - c. Determine loads based on pressures indicated below:
 - 1) Corner Zone: Within **<Insert distance>** of building corners, uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
 - 2) Other Than Corner Zone: Uniform pressure of **<Insert design wind pressure>**, acting inward, and **<Insert design wind pressure>**, acting outward.
- B. Windborne-Debris-Impact Resistance: Louvers located within 30 feet (9.1 m) of grade pass **[basic]** **[enhanced]** protection, when tested in accordance with AMCA 540.
- C. Seismic Performance:
 1. As indicated on Drawings.
 2. Louvers, including attachments to other construction, withstand the effects of earthquake motions determined in accordance with [ASCE/SEI 7] **<Insert requirement>**.
 - a. Design earthquake spectral response acceleration, short period (Sds) for Project is **<Insert value>**.
 - b. Component Importance Factor: **[1.5]** **[1.0]**.
- D. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.
- E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 1. Temperature Change (Range): 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.
- F. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED EXTRUDED-ALUMINUM LOUVERS

- A. Horizontal, Wind-Driven-Rain-Resistant Louver, Extruded Aluminum **<Insert drawing designation>**:
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following]** **[provide products by one of the following]** **[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]**:

- a. Air Balance; a division of MESTEK, Inc.
- b. Air Flow Company, Inc.
- c. Airline Louvers; a division of Mestek, Inc.
- d. Airolite Company, LLC (The).
- e. All-Lite Architectural Products.
- f. American Warming and Ventilating; a Mestek Architectural Group company.
- g. Architectural Louvers; Harray, LLC.
- h. Arrow United Industries.
- i. Construction Specialties, Inc.
- j. Greenheck Fan Corporation.
- k. Industrial Louvers Inc.
- l. NCA Manufacturing, Inc.
- m. Pottorff.
- n. Reliable Products, Inc.
- o. Ruskin Company.
- p. Safe Air - Dowco Products.
- q. United Enertech.
- 2. Louver Depth: Insert dimension.
- 3. Frame and Blade Nominal Thickness: Not less than 0.060 inch (1.52 mm) for blades and 0.080 inch (2.03 mm) for frames.
- 4. Louver Performance Ratings:
 - a. Free Area: Not less than Insert value for 48-inch- (1220-mm-) wide by 48-inch- (1220-mm-) high louver.
 - b. Air Performance: Not more than Insert value static pressure drop at Insert value free-area exhaust intake velocity.
 - c. Wind-Driven Rain Performance: Not less than 95 percent effectiveness when subjected to a rainfall rate of 3 inches (75 mm) per hour and a wind speed of 29 mph (13 m/s) at a core-area intake velocity of Insert value.
- 5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

- A. General: Provide screen at each exterior louver .
 - 1. Screen Location for Fixed Louvers: Interior face.
 - 2. Screening Type: Insect screening.
- B. Secure screen frames to louver frames with [**stainless steel machine screws**] [**machine screws with heads finished to match louver**], spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 - 1. Metal: Same type and form of metal as indicated for louver to which screens are attached.[**Reinforce extruded-aluminum screen frames at corners with clips.**]
 - 2. Finish: Same finish as louver frames to which louver screens are attached .
 - 3. Type: Rewirable frames with a driven spline or insert .
- D. Louver Screening for Aluminum Louvers:
 - 1. Bird Screening, Aluminum: 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.
 - 2. Bird Screening, Stainless Steel: 1/2-inch- (13-mm-) square mesh, 0.047-inch (1.19-mm) wire.
 - 3. Bird Screening, Flattened, Expanded Aluminum: 3/4 by 0.050 inch (19 by 1.27 mm) thick.

4. Insect Screening, Aluminum: 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) wire.
5. Insect Screening, Stainless Steel: 18-by-18 (1.4-by-1.4-mm) mesh, 0.009-inch (0.23-mm) wire.

2.5 MATERIALS

- A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5, T-52, or T6.
- B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A653/A653M, G60 (Z180) G90 (Z275) zinc coating, mill phosphatized.
- D. Stainless Steel Sheet: ASTM A240/A240M, Type 304, No. 2B finish No. 2D finish No. 4 finish, with grain running parallel to length of blades and frame members No. 4 finish, with grain running perpendicular to length of blades and frame members No. 4 finish, with grain running perpendicular to length of blades and parallel to length of frame members No. 6 finish.
- E. Fasteners: Use types and sizes to suit unit installation conditions.
 1. Use [**Phillips flat-head**] [**hex-head or Phillips pan-head**] [**tamper-resistant**] screws for exposed fasteners unless otherwise indicated.
 2. For fastening aluminum, use aluminum or 300 series stainless steel fasteners.
 3. For fastening galvanized steel, use hot-dip-galvanized-steel or 300 series stainless steel fasteners.
 4. For fastening stainless steel, use 300 series stainless steel fasteners.
 5. For color-finished louvers, use fasteners with heads that match color of louvers.
- F. Postinstalled Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless steel components, with allowable load or strength design capacities calculated in accordance with ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified testing agency.
- G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.
- H. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] <Insert value> percent.
- I. Recycled Content of Aluminum Components: Postconsumer recycled content plus one-half of preconsumer recycled content not less than [25] [50] <Insert value> percent.
- J. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.

2.6 FABRICATION

- A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

- B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.
 - 1. Continuous Vertical Assemblies: Fabricate units without interrupting blade-spacing pattern [**unless horizontal mullions are indicated**] [**where indicated**].
 - 2. Horizontal Mullions: Provide horizontal mullions at joints [**unless continuous vertical assemblies are indicated**] [**where indicated**].
 - C. Maintain equal louver blade spacing[, **including separation between blades and frames at head and sill,**] to produce uniform appearance.
 - D. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 - 1. Frame Type: [**Channel**] [**Exterior flange**] [**Interior flange**] unless otherwise indicated.
 - E. Include supports, anchorages, and accessories required for complete assembly.
 - F. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer, or 72 inches (1830 mm) o.c., whichever is less.
 - 1. Fully Recessed Mullions: Where indicated, provide mullions fully recessed behind louver blades. Where length of louver exceeds fabrication and handling limitations, fabricate with close-fitting blade splices designed to permit expansion and contraction.
 - 2. Semirecessed Mullions: Where indicated, provide mullions partly recessed behind louver blades, so louver blades appear continuous. Where length of louver exceeds fabrication and handling limitations, fabricate with interlocking split mullions and close-fitting blade splices designed to permit expansion and contraction.
 - 3. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
 - 4. Exterior Corners: Prefabricated corner units with mitered [**and welded blades**] [**blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.
 - G. Provide [**subsills made of same material as louvers**] [**or**] [**extended sills**] for recessed louvers.
 - H. Join frame members to each other and to fixed louver blades with fillet welds [**concealed from view**] [, **threaded fasteners, or both, as standard with louver manufacturer**] unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.
- 2.7 ALUMINUM FINISHES
- A. Finish louvers after assembly.
 - B. Color Anodic Finish: AAMA 611, AA-M12C22A32/A34, Class II, 0.010 mm or thicker.
 - 1. Color: Dark bronze .

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.
- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 07 9200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

- A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 09 0561.13 - MOISTURE VAPOR EMISSION CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes fluid-applied, resin-based, membrane-forming systems that control the moisture-vapor-emission rate of high-moisture, interior concrete to prepare it for floor covering installation.
- B. Contractor's Responsibility: Suitability of concrete slab to meet vapor emission limits as required by scheduled floor finish materials is the responsibility of the Contractor. Where concrete slab vapor emission exceeds limits, apply topical vapor retarders specified in this section.
- C. Related Requirements:
 - 1. Section 03 0513 "Common Work Results for Cast-in-Place Concrete Slabs."
 - 2. Section 03 3000 "Cast-in-Place Concrete" for concrete floor slabs.
 - 3. Section 09 6723 "Resinous Flooring."

1.2 DEFINITIONS

- A. MVE: Moisture vapor emission.
- B. MVER: Moisture vapor emission rate.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For coatings, indicating VOC content.
 - 2. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.

1.4 INFORMATIONAL SUBMITTALS

- A. Certifications: Furnish written certification that the manufacturer has verified the compatibility between the vapor retarder provided and the flooring product scheduled to be applied, including adhesives and floor leveling materials.
- B. Flooring Manufacturer Acceptance of Vapor Retarder Application: Furnish a signed written statement obtained from flooring manufacturer, stating that the water vapor emission levels, after application of vapor retarders, are acceptable and suitable for their flooring application.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Employs factory-trained personnel who are available for consultation and Project-site inspection.

- B. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- C. Provide the following upon request:
 - 1. Qualification Data: For installer and manufacturer.
 - 2. Product Test Reports: For each MVE-control system, for tests performed by manufacturer and witnessed by a qualified testing agency.
 - 3. Preinstallation testing reports.
 - 4. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating directions for storage and mixing with other components.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Comply with MVE-control system manufacturer's written instructions for substrate and ambient temperatures, humidity, ventilation, and other conditions affecting system installation.
 - 1. Store system components in a temperature-controlled environment and protected from weather and at ambient temperature of not less than 65 deg F (18 deg C) and not more than 85 deg F (29.4 deg C) at least 48 hours before use.
 - 2. Maintain ambient temperature and relative humidity in installation areas within range recommended in writing by MVE-control system manufacturer, but not less than 65 deg F (18 deg C) or more than 85 deg F (29.4 deg C) and not less than 40 or more than 60 percent relative humidity, for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.
 - 3. Install MVE-control systems where concrete surface temperatures will remain a minimum of 5 deg F (3 deg C) higher than the dew point for ambient temperature and relative humidity conditions in installation areas for 48 hours before installation, during installation, and for 48 hours after installation unless longer period is recommended in writing by manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. MVE-Control System Capabilities: Capable of suppressing MVE without failure where installed on concrete that exhibits the following conditions:
 - 1. MVER: Maximum 25 lb of water/1000 sq. ft. (11.34 kg of water/92.9 sq. m) when tested according to ASTM F1869.
 - 2. Relative Humidity: Maximum 100 percent when tested according to ASTM F2170 using in situ probes.
- B. Water-Vapor Transmission: Through MVE-control system, maximum 0.10 perm (5.75 ng/Pa x s x sq. m) when tested according to ASTM E96/E96M.
- C. Tensile Bond Strength: For MVE-control system, greater than 200 psi (1.38 MPa) with failure in the concrete according to ASTM D7234.

2.2 MVE-CONTROL SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advanced Moisture Control, Inc.
 - 2. ARDEX Americas.
 - 3. LATICRETE SUPERCAP, LLC.
 - 4. MAPEI Corporation.
 - 5. USG Corporation.
- B. MVE-Control System: ASTM F3010-qualified, fluid-applied, two-component, epoxy-resin, membrane-forming system; formulated for application on concrete substrates to reduce MVER to level required for installation of floor coverings indicated and acceptable to manufacturers of floor covering products indicated, including adhesives.
 - 1. Substrate Primer: Provide MVE-control system manufacturer's concrete-substrate primer if required for system indicated by substrate conditions.
 - 2. Cementitious Underlayment Primer: If required for subsequent installation of cementitious underlayment products, provide MVE-control system manufacturer's primer to ensure adhesion of products to MVE-control system.
 - 3. VOC Content: Provide coating with VOC content of 100 g/L or less.
 - 4. Low-Emitting Materials: Coating shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 ACCESSORIES

- A. Patching and Leveling Material: Moisture-, mildew-, and alkali-resistant product recommended in writing by MVE-control system manufacturer and with minimum of 3000-psi (20.68-MPa) compressive strength after 28 days when tested according to ASTM C109/C109M.
- B. Crack-Filling Material: Resin-based material recommended in writing by MVE-control system manufacturer for sealing concrete substrate crack repair.
- C. Cementitious Underlayment: If required to maintain manufacturer's warranty, provide MVE-control system manufacturer's hydraulic cement-based underlayment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Installation of system indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Preinstallation Testing:
1. Testing Agency: Owner will engage a qualified testing agency to perform tests.
 2. Alkalinity Testing: Perform pH testing according to ASTM F710. Install MVE-control system in areas where pH readings are less than 7.0 and in areas where pH readings are greater than 8.5.
 3. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Install MVE-control system in locations where concrete substrate MVER exceeds 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
 - b. Internal Relative Humidity Test: Using in situ probes, ASTM F2170. Install MVE-control system in locations where concrete substrates exhibit relative humidity level greater than 75 percent.
 4. Tensile-Bond-Strength Testing: For typical locations indicated to receive installation of MVE-control system, install minimum 100-sq. ft. (9.29-sq. m) area of MVE-control system to prepared concrete substrate and test according to ASTM D7234.
 - a. Proceed with installation only where tensile bond strength is greater than 200 psi (1.38 MPa) with failure in the concrete.
- B. Concrete Substrates: Prepare and clean substrates according to MVE-control system manufacturer's written instructions to ensure adhesion of system to concrete.
1. Remove coatings and other substances that are incompatible with MVE-control system and that contain soap, wax, oil, or silicone, using mechanical methods recommended in writing by MVE-control system manufacturer. Do not use solvents.
 2. Provide concrete surface profile complying with ICRI 310.2R CSP 3 by shot blasting using apparatus that abrades the concrete surface with shot, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
 3. After shot blasting, repair damaged and deteriorated concrete according to MVE-control system manufacturer's written instructions.
 4. Protect substrate voids and joints to prevent resins from flowing into or leaking through them.
 5. Fill surface depressions and irregularities with patching and leveling material.
 6. Fill surface cracks, grooves, control joints, and other nonmoving joints with crack-filling material.
 7. Allow concrete to dry, undisturbed, for period recommended in writing by MVE-control system manufacturer after surface preparation, but not less than 24 hours.
 8. Before installing MVE-control systems, broom sweep and vacuum prepared concrete.
- C. Protect walls, floor openings, electrical openings, door frames, and other obstructions during installation.

3.3 INSTALLATION

- A. Install MVE-control system according to ASTM F3010 and manufacturer's written instructions to produce a uniform, monolithic surface free of surface deficiencies such as pin holes, fish eyes, and voids.
1. Install primers as required to comply with manufacturer's written instructions.

- B. Do not apply MVE-control system across substrate expansion, isolation, and other moving joints.
- C. Apply system, including component coats if any, in thickness recommended in writing by MVE-control system manufacturer for MVER indicated by preinstallation testing.
- D. Cure MVE-control system components according to manufacturer's written instructions. Prevent contamination or other damage during installation and curing processes.
- E. After curing, examine MVE-control system for surface deficiencies. Repair surface deficiencies according to manufacturer's written instructions.
- F. Install cementitious underlayment over cured membrane if required to maintain manufacturer's warranty and in thickness required to maintain the warranty.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform installation inspections.
- B. Installation Inspections: Inspect substrate preparation and installation of system components to ensure compliance with manufacturer's written instructions and to ensure that a complete MVE-control system is installed without deficiencies.
 - 1. Verify that surface preparation meets requirements.
 - 2. Verify that component coats and complete MVE-control-system film thicknesses comply with manufacturer's written instructions.
 - 3. Verify that MVE-control-system components and installation areas that evidence deficiencies are repaired according to manufacturer's written instructions.
- C. MVE-control system will be considered defective if it does not pass inspections.

3.5 PROTECTION

- A. Protect MVE-control system from damage, wear, dirt, dust, and other contaminants before floor covering installation. Use protective methods and materials, including temporary coverings, recommended in writing by MVE-control system manufacturer.
- B. Do not allow subsequent preinstallation examination and testing for floor covering installation to damage, puncture, or otherwise compromise the MVE-control system membrane.

END OF SECTION

SECTION 09 2116.23 - GYPSUM BOARD SHAFT WALL ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

1. Section includes gypsum board shaft wall assemblies.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 1. Review requirements for control joint locations.

1.3 ACTION SUBMITTALS

- A. Product Data: For each component of gypsum board shaft wall assembly.
- B. Sustainable Design Submittals:
 1. Environmental Product Declaration (EPD): For each product.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and support them on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Comply with gypsum-shaftliner-board manufacturer's written instructions.
- B. Do not install finish panels until installation areas are enclosed and conditioned. Use moisture- and mold-resistant panels or moisture- and mold-resistant fiberglass-mat faced panels if installation must take place prior to installation area being enclosed and conditioned.
- C. Do not install panels that are wet, moisture damaged, or mold damaged.
 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or spotty surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.
- B. STC-Rated Assemblies: Provide materials and construction identical to those of assemblies tested according to ASTM E90 and classified according to ASTM E413 by a testing and inspecting agency.

- C. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- D. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- E. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.

2.2 GYPSUM BOARD SHAFT WALL ASSEMBLIES

- A. Fire-Resistance Rating: As indicated on Drawings 1 hour 2 hours 3 hours 4 hours Insert rating.
- B. STC Rating: As indicated on Drawings 51, minimum Insert rating.
- C. Gypsum Shaftliner Board:
 - 1. Type X: ASTM C1396/C1396M; manufacturer's proprietary fire-resistive liner panels with paper faces, 1 inch (25.4 mm) thick, with double beveled long edges.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) American Gypsum.
 - 2) CertainTeed Corporation.
 - 3) Georgia-Pacific Gypsum LLC.
 - 4) National Gypsum Company.
 - 5) USG Corporation.
 - 2. Moisture- and Mold-Resistant Type X: ASTM C1396/C1396M; manufacturer's proprietary fire-resistive liner panels with ASTM D3273 mold-resistance score of 10 as rated according to ASTM D3274, 1 inch (25.4 mm) thick, and with double beveled long edges.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) American Gypsum.
 - 2) CertainTeed Corporation.
 - 3) CertainTeed Gypsum.
 - 4) Georgia-Pacific Gypsum LLC.
 - 5) National Gypsum Company.
 - 6) USG Corporation.
- D. Non-Load-Bearing Steel Framing, General: Complying with ASTM C645 requirements for metal unless otherwise indicated and complying with requirements for fire-resistance-rated assembly indicated.
 - 1. Protective Coating: ASTM A653/A653M, G60 (Z180), hot-dip galvanized unless otherwise indicated.
- E. Studs: Manufacturer's standard profile for repetitive, corner, and end members as follows:
 - 1. Depth: As indicated.
 - 2. Minimum Base-Metal Thickness: As indicated.

- F. Runner Tracks: Manufacturer's standard J-profile track with manufacturer's standard long-leg length, but at least 2 inches (51 mm) long and matching studs in depth.
1. Minimum Base-Metal Thickness: As indicated.
- G. Firestop Tracks: Top runner manufactured to allow partition heads to expand and contract with movement of the structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CEMCO; California Expanded Metal Products Co.
 - b. ClarkDietrich.
 - c. Fire Trak Corp.
 - d. MarinoWARE.
 - e. Metal-Lite.
 - f. SCAFCO Steel Stud Company.
 - g. Steel Construction Systems.
 - h. The Steel Network, Inc.
- H. Finish Panels: As indicated. .

2.3 AUXILIARY MATERIALS

- A. Provide auxiliary materials that comply with shaft wall manufacturer's written instructions.
- B. Trim Accessories: Cornerbead, edge trim, and control joints of material and shapes as specified in Section 09 2900 "Gypsum Board" Section 09 2613 "Gypsum Veneer Plastering" that comply with gypsum board shaft wall assembly manufacturer's written instructions for application indicated.
- C. Steel Drill Screws: ASTM C1002 unless otherwise indicated.
- D. Track Fasteners: Power-driven fasteners of size and material required to withstand loading conditions imposed on shaft wall assemblies without exceeding allowable design stress of track, fasteners, or structural substrates in which anchors are embedded.
1. Expansion Anchors: Fabricated from corrosion-resistant materials, with allowable load or strength design capacities calculated according to ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing per ASTM E488/E488M conducted by a qualified testing agency.
 2. Power-Actuated Anchors: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with allowable load capacities calculated according to ICC-ES AC70, greater than or equal to the design load, as determined by testing per ASTM E1190 conducted by a qualified testing agency.
- E. Acoustical Sealant: Section 07 9219 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Sprayed Fire-Resistive Materials: Coordinate with gypsum board shaft wall assemblies so both elements of Work remain complete and undamaged. Patch or replace sprayed fire-resistive materials removed or damaged during installation of shaft wall assemblies to comply with requirements specified in Section 07 8100 "Applied Fire Protection."
- B. After sprayed fire-resistive materials are applied, remove only to extent necessary for installation of gypsum board shaft wall assemblies and without reducing the fire-resistive material thickness below that which is required to obtain fire-resistance rating indicated. Protect remaining fire-resistive materials from damage.

3.3 INSTALLATION

- A. General: Install gypsum board shaft wall assemblies to comply with requirements of fire-resistance-rated assemblies indicated and manufacturer's written installation instructions.
- B. Do not bridge building expansion joints with shaft wall assemblies; frame both sides of expansion joints with furring and other support.
- C. Install supplementary framing in gypsum board shaft wall assemblies around openings and as required for blocking, bracing, and support of gravity and pullout loads of fixtures, equipment, services, heavy trim, furnishings, wall-mounted door stops, and similar items that cannot be supported directly by shaft wall assembly framing.
 - 1. Reinforcing: Provide where items attach directly to shaft wall assembly as indicated on Drawings; accurately position and secure behind at least one layer of face panel.
- D. Penetrations: At penetrations in shaft wall, maintain fire-resistance rating of shaft wall assembly by installing supplementary steel framing around perimeter of penetration and fire protection behind boxes containing wiring devices, elevator call buttons and floor indicators, and similar items.
- E. Isolate perimeter of gypsum panels from building structure to prevent cracking of panels while maintaining continuity of fire-rated construction.
- F. Firestop Tracks: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

- G. Control Joints: Install control joints according to ASTM C840, including compliance with ASTM 20.3.1 - 20.4 for control joint spacing, whether or not such joints are indicated on Drawings, in specific locations approved by Architect and as follows, while maintaining fire-resistance rating of gypsum board shaft wall assemblies.
 - 1. Install at changes in backup material.
 - 2. Framed Openings (Both Sides of Partition):
 - a. Doors: Install above both jambs unless indicated or directed otherwise.
 - b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.
 - 3. Install at other locations indicated on Drawings.
- H. Sound-Rated Shaft Wall Assemblies: Seal gypsum board shaft walls with acoustical sealant at perimeter of each assembly where it abuts other work and at joints and penetrations within each assembly.
- I. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

3.4 PROTECTION

- A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- B. Remove and replace panels that are wet, moisture damaged, or mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, and irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

SECTION 09 2216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Framing systems.
 - 2. Suspension systems.
 - 3. Grid suspension systems.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Framing systems.
- B. Sustainable Design Submittals:
 - 1. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.

1.3 QUALITY ASSURANCE

- A. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association the Steel Framing Industry Association the Steel Stud Manufacturers Association or the Supreme Steel Framing System Association.
- B. Provide the following upon request:
 - 1. Product Certificates: For each type of code-compliance certification for studs and tracks.
 - 2. Evaluation Reports: For firestop tracks post-installed anchors and power-actuated fasteners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Notify manufacturer of damaged materials received prior to installation.
- B. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.
- C. Protect cold-formed metal framing from corrosion, deformation, and other damage during delivery, storage, and handling as required by AISI S202, "Code of Standard Practice for Cold-Formed Steel Structural Framing."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, in accordance with ASTM E119 by an independent testing agency.

- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.
- C. Design framing systems in accordance with AISI S220, "North American Specification for the Design of Cold-Formed Steel Framing - Nonstructural Members," unless otherwise indicated.
- D. Design Loads: As indicated on architectural Drawings or 5 lbf/sq. ft. (239 Pa) minimum as required by the IBC.

2.2 FRAMING SYSTEMS

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- B. Framing Members, General: Comply with AISI S220 for conditions indicated.
 - 1. Steel Sheet Components: Comply with AISI S220 requirements for metal unless otherwise indicated
 - 2. Protective Coating: Comply with [ASTM C645] [AISI S220]; ASTM A653/A653M, G60 (Z180); or coating with equivalent corrosion resistance. Galvannealed products are unacceptable.
 - a. Coating demonstrates equivalent corrosion resistance with an evaluation report acceptable to authorities having jurisdiction.
- C. Studs and Track: AISI S220.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CEMCO; California Expanded Metal Products Co.
 - b. ClarkDietrich.
 - c. Custom Stud.
 - d. Jaimes Industries.
 - e. MarinoWARE.
 - f. MBA Building Supplies.
 - g. MRI Steel Framing, LLC.
 - h. Phillips Manufacturing Co.
 - i. SCAFCO Steel Stud Company.
 - j. Steel Construction Systems.
 - k. Steel Network, Inc. (The).
 - l. Telling Industries.
 - 2. Minimum Base-Steel Thickness: As indicated on Drawings .
 - 3. Depth: As indicated on Drawings .
- D. Slip-Type Head Joints: Where indicated, provide one of the following:
 - 1. Clip System: Clips designed for use in head-of-wall deflection conditions that provide a positive attachment of studs to tracks while allowing 2-inch (51-mm) minimum vertical movement.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) CEMCO; California Expanded Metal Products Co.
 - 2) ClarkDietrich.

- 3) Fire Trak Corp.
 - 4) MarinoWARE.
 - 5) SCAFCO Steel Stud Company.
 - 6) Steel Construction Systems.
 - 7) Steel Network, Inc. (The).
 - 8) Super Stud Building Products Inc.
2. Single Long-Leg Track System: Top track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs, installed with studs friction fit into top track and with continuous bridging located within 12 inches (305 mm) of the top of studs to provide lateral bracing.
 3. Double-Track System: Top outer tracks, inside track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.
 4. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) CEMCO; California Expanded Metal Products Co.
 - 2) ClarkDietrich.
 - 3) MarinoWARE.
 - 4) MBA Building Supplies.
 - 5) Metal-Lite.
 - 6) SCAFCO Steel Stud Company.
 - 7) Steel Construction Systems.
 - 8) Steel Network, Inc. (The).
 - 9) Telling Industries.
- E. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich.
 - b. Fire Trak Corp.
 - c. MarinoWARE.
 - d. Metal-Lite.
- F. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich.
 - b. MarinoWARE.
 - c. MBA Building Supplies.
 - d. MRI Steel Framing, LLC.
 - e. SCAFCO Steel Stud Company.
 - f. Steel Construction Systems.
 - g. Steel Network, Inc. (The).
 2. Minimum Base-Steel Thickness: As indicated on Drawings .

- G. Cold-Rolled Channel Bridging: Steel, 0.0538-inch (1.367-mm) minimum base-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich.
 - b. MarinoWARE.
 - c. MBA Building Supplies.
 - d. MRI Steel Framing, LLC.
 - e. SCAFCO Steel Stud Company.
 - f. Steel Construction Systems.
 2. Depth: As indicated on Drawings .
 3. Clip Angle: Not less than 1-1/2 by 1-1/2 inches (38 by 38 mm), 0.068-inch- (1.72-mm-) thick, galvanized steel.
- H. Hat-Shaped, Rigid Furring Channels:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich.
 - b. Jaimes Industries.
 - c. MarinoWARE.
 - d. MBA Building Supplies.
 - e. MRI Steel Framing, LLC.
 - f. SCAFCO Steel Stud Company.
 - g. Steel Construction Systems.
 2. Minimum Base-Steel Thickness: As indicated on Drawings .
 3. Depth: As indicated on Drawings .
- I. Cold-Rolled Furring Channels: 0.053-inch (1.34-mm) uncoated-steel thickness, with minimum 1/2-inch- (13-mm-) wide flanges.
1. Depth: As indicated on Drawings .
 2. Furring Brackets: Adjustable, corrugated-edge-type steel sheet with minimum uncoated-steel thickness of 0.0329 inch (0.8 mm).
 3. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.
- J. Z-Shaped Furring: With slotted or nonslotted web, face flange of 1-1/4 inches (32 mm), wall attachment flange of 3/4 inch (19 mm), minimum uncoated-steel thickness of 0.0179 inch (0.455 mm), and depth required to fit insulation thickness indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ClarkDietrich.
 - b. MarinoWARE.
 - c. MBA Building Supplies.
 - d. MRI Steel Framing, LLC.
 - e. SCAFCO Steel Stud Company.
 - f. Steel Construction Systems.
 - g. Steel Network, Inc. (The).

2.3 AUXILIARY MATERIALS

- A. General: Provide auxiliary materials that comply with referenced installation standards.
 - 1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.
- B. Isolation Strip at Exterior Walls: Provide one of the following:
 - 1. Asphalt-Saturated Organic Felt: ASTM D226/D226M, Type I (No. 15 asphalt felt), nonperforated.
 - 2. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch (3.2 mm) thick, in width to suit steel stud size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.
 - 1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.
- B. Coordination with Sprayed Fire-Resistive Materials:
 - 1. Before sprayed fire-resistive materials are applied, attach offset anchor plates or ceiling tracks to surfaces indicated to receive sprayed fire-resistive materials. Where offset anchor plates are required, provide continuous plates fastened to building structure not more than 24 inches (610 mm) o.c.
 - 2. After sprayed fire-resistive materials are applied, remove them only to extent necessary for installation of non-load-bearing steel framing. Do not reduce thickness of fire-resistive materials below that are required for fire-resistance ratings indicated. Protect adjacent fire-resistive materials from damage.

3.3 INSTALLATION, GENERAL

- A. Installation Standard: ASTM C754.
 - 1. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.
- B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

- C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.
- D. Install bracing at terminations in assemblies.
- E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.4 INSTALLATION OF FRAMING SYSTEMS

- A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.
 - 1. Single-Layer Application: As required by horizontal deflection performance requirements unless otherwise indicated.
 - 2. Multilayer Application: As required by horizontal deflection performance requirements unless otherwise indicated.
 - 3. Tile Backing Panels: As required by horizontal deflection performance requirements unless otherwise indicated.
- B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.
- C. Install studs so flanges within framing system point in same direction.
- D. Install tracks at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.
 - 1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
 - 2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.
 - a. Install two studs at each jamb unless otherwise indicated.
 - b. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch (13-mm) clearance from jamb stud to allow for installation of control joint in finished assembly.
 - c. Extend jamb studs through suspended ceilings and attach to underside of overhead structure.
 - 3. Other Framed Openings: Frame openings other than door openings the same as required for door openings unless otherwise indicated. Install framing below sills of openings to match framing required above door heads.
 - 4. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.
 - a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.
 - 5. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
- E. Direct Furring:

1. Attach to concrete or masonry with stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
- F. Z-Shaped Furring Members:
1. Erect insulation, specified in Section 07 2100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced 24 inches (610 mm) o.c.
 2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
 3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches (305 mm) from corner and cut insulation to fit.
- G. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.
- 3.5 FIELD QUALITY CONTROL
- A. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet (3 mm in 3.6 m) measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

SECTION 09 2900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Interior gypsum board.
 - 2. Exterior gypsum board for ceilings and soffits.
 - 3. Backing panels.
- B. Related Requirements:
 - 1. Section 06 1600 "Sheathing" for gypsum sheathing for exterior walls.
 - 2. Section 07 9219 "Acoustical Joint Sealants" for acoustical joint sealants installed in gypsum board assemblies.
 - 3. Section 09 2116.23 "Gypsum Board Shaft Wall Assemblies" for metal shaft-wall framing, gypsum shaft liners, and other components of shaft-wall assemblies.
 - 4. Section 09 2216 "Non-Structural Metal Framing" for non-structural steel framing and suspension systems that support gypsum board panels.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review requirements for control joint locations.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.
- C. Sustainable Design Submittals:
 - 1. Environmental Product Declaration (EPD): For each product.
 - 2. Product Data: For adhesives and sealants, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Test Reports: For ceiling and wall materials, indicating compliance with requirements for low-emitting materials.

1.4 DELIVERY, STORAGE AND HANDLING

- A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.5 FIELD CONDITIONS

- A. Environmental Limitations: Comply with ASTM C840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

- B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned. Use mold-resistant gypsum board or glass-mat interior gypsum board if installation must take place prior to installation areas being enclosed and conditioned.
- C. Do not install panels that are wet, moisture damaged, and mold damaged.
 - 1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
 - 2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of gypsum panel and joint finishing material from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 PERFORMANCE REQUIREMENTS

- A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E119 by an independent testing agency.
- B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated according to ASTM E90 and classified according to ASTM E413 by an independent testing agency.
- C. Ceiling and wall materials shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 GYPSUM BOARD, GENERAL

- A. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- B. Regional Materials: Products shall be manufactured within 100 miles (160 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 100 miles (160 km) of Project site.
- C. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.4 INTERIOR GYPSUM BOARD (GWB-01, GWB-02)

- A. Gypsum Board, Type X: ASTM C1396/C1396M.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Gypsum.
 - b. Certaineed; SAINT-GOBAIN.

- c. Georgia-Pacific Gypsum LLC.
- d. National Gypsum Company.
- e. USG Corporation; EcoSmart Panels Firecode X (Basis-of-Design).
- 2. Thickness: 5/8 inch (15.9 mm).
- 3. Long Edges: Tapered .

B. Mold-Resistant Gypsum Board: ASTM C1396/C1396M. With moisture- and mold-resistant core and paper surfaces.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Gypsum.
 - b. Certaineed; SAINT-GOBAIN.
 - c. Georgia-Pacific Gypsum LLC.
 - d. National Gypsum Company.
 - e. USG Corporation.
- 2. Core: 5/8 inch (15.9 mm), Type X.
- 3. Long Edges: Tapered.
- 4. Mold Resistance: ASTM D3273, score of 10 as rated according to ASTM D3274.

2.5 SPECIALTY GYPSUM BOARD

A. Glass-Mat Interior Gypsum Board: ASTM C1658/C1658M. With fiberglass mat laminated to both sides. Specifically designed for interior use.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georgia-Pacific Gypsum LLC.
 - b. National Gypsum Company.
 - c. USG Corporation.
- 2. Core: 5/8 inch (15.9 mm), Type X .
- 3. Long Edges: Tapered.
- 4. Mold Resistance: ASTM D3273, score of 10 as rated according to ASTM D3274.

2.6 EXTERIOR GYPSUM BOARD FOR CEILINGS AND SOFFITS

A. Exterior Gypsum Soffit Board: ASTM C1396/C1396M, with manufacturer's standard edges.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Gypsum.
 - b. Certaineed; SAINT-GOBAIN.
 - c. Continental Building Products, LLC.
 - d. Georgia-Pacific Gypsum LLC.
 - e. USG Corporation.
- 2. Core: 5/8 inch (15.9 mm), Type X.

2.7 BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Board: ASTM C1178/C1178M, with manufacturer's standard edges.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certaineed; SAINT-GOBAIN.

- b. Georgia-Pacific Gypsum LLC.
- c. National Gypsum Company.
- d. USG Corporation.
- 2. Core: As indicated on Drawings .
- 3. Mold Resistance: ASTM D3273, score of 10 as rated according to ASTM D3274.

2.8 TRIM ACCESSORIES

- A. Interior Trim: ASTM C1047.
 - 1. Material: Galvanized or aluminum-coated steel sheet, rolled zinc, plastic, or paper-faced galvanized-steel sheet .
 - 2. Shapes:
 - a. Cornerbead.
 - b. LC-Bead: J-shaped; exposed long flange receives joint compound.
 - c. L-Bead: L-shaped; exposed long flange receives joint compound.
 - d. U-Bead: J-shaped; exposed short flange does not receive joint compound.
 - e. Expansion (control) joint.
- B. Acoustical Mullion Trim Covers.
 - 1. General: Provide sound barrier mullion trim caps of design, basic profile, materials, and operation indicated. Provide units with capability to accommodate variations in adjacent surfaces.
 - a. Furnish units in lengths of sufficient additional length to allow for field trimming to required length to match variations in construction tolerances of adjacent systems.
- C. Exterior Trim: ASTM C1047.
 - 1. Material: Hot-dip galvanized-steel sheet, plastic, or rolled zinc.
 - 2. Shapes:
 - a. Cornerbead.
 - b. LC-Bead: J-shaped; exposed long flange receives joint compound.
 - c. Expansion (Control) Joint: One-piece, rolled zinc with V-shaped slot and removable strip covering slot opening.

2.9 JOINT TREATMENT MATERIALS

- A. General: Comply with ASTM C475/C475M.
- B. Joint Tape:
 - 1. Interior Gypsum Board: Paper.
 - 2. Exterior Gypsum Soffit Board: Paper.
 - 3. Glass-Mat Gypsum Sheathing Board: 10-by-10 glass mesh.
 - 4. Backing Panels: As recommended by panel manufacturer.
- C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.
 - 1. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.
 - a. Use setting-type compound for installing paper-faced metal trim accessories.
 - 2. Fill Coat: For second coat, use drying-type, all-purpose compound.
 - 3. Finish Coat: For third coat, use drying-type, all-purpose compound.

- D. Joint Compound for Exterior Applications:
 - 1. Exterior Gypsum Soffit Board: Use setting-type taping compound and setting-type, sandable topping compound.
- E. Joint Compound for Backing Panels:
 - 1. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.
 - 2. Cementitious Backer Units: As recommended by backer unit manufacturer.

2.10 AUXILIARY MATERIALS

- A. Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.
- B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.
 - 1. Adhesives shall have a VOC content of 50 g/L or less.
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Steel Drill Screws: ASTM C1002 unless otherwise indicated.
 - 1. Use screws complying with ASTM C954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.
 - 2. For fastening cementitious backer units, use screws of type and size recommended by panel manufacturer.
- D. Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.
 - 1. Manufacturers and Products: Subject to compliance with requirements, provide products by one of the following:
 - a. Owens Corning; Thermafiber SAFB
 - b. Johns Manville; MinWool SAFB.
 - c. Rockwool; Safe'n'Sound.
 - 2. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.
 - 3. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- E. Acoustical Sealant: As specified in Section 07 9219 "Acoustical Joint Sealants."
 - 1. Sealant shall have a VOC content of 250 g/L or less.
 - 2. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. Thermal Insulation: As specified in Section 07 2100 "Thermal Insulation."
- G. Vapor Retarder: As specified in Section 07 2600 "Vapor Retarders."

- H. Firestop Putty Pads for Electrical Boxes: Listed intumescent moldable firestop putty pads.
 - 1. Product: Subject to compliance with requirements, provide one of the following:
 - a. Hilti Corporation; CP 617 6" x 7" Putty Pad or CP 617L 7" x 7" Putty Pad.
 - b. Kinetics Noise Control; IsoBacker.
 - c. RectorSeal Firestop Solutions; Metacaulk Box Guard.
 - d. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.
- I. Acoustic Putty Pads for Electrical Boxes: Asbestos-free, putty pads composed of polybutene-butyl and inert fillers.
 - 1. Product: Subject to compliance with requirements, provide one of the following:
 - a. Kinetics Noise Control; IsoBacker.
 - b. QuietRock; QuietPutty.
 - c. Specified Technologies Inc. (STI); SpecSeal Series SSP Putty Pad.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION AND FINISHING OF PANELS, GENERAL

- A. Comply with ASTM C840.
- B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.
- C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.
- D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.
- E. Form control and expansion joints with space between edges of adjoining gypsum panels.
- F. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.
 - 1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.

2. Fit gypsum panels around ducts, pipes, and conduits.
 3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch- (6.4- to 9.5-mm-) wide joints to install sealant.
- G. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.
- H. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.
- I. STC-Rated Assemblies: Seal construction at perimeters, behind control joints, and at openings and penetrations with a continuous bead of acoustical sealant. Install acoustical sealant at both faces of partitions at perimeters and through penetrations. Comply with ASTM C919 and with manufacturer's written instructions for locating edge trim and closing off sound-flanking paths around or through assemblies, including sealing partitions above acoustical ceilings.
- J. Install sound attenuation blankets before installing gypsum panels unless blankets are readily installed after panels have been installed on one side.

3.3 INSTALLATION OF INTERIOR GYPSUM BOARD

- A. Install interior gypsum board in the following locations:
1. Type X: As indicated on Drawings.
 2. Mold-Resistant Type: As indicated on Drawings.
 3. Glass-Mat Interior Type: As indicated on Drawings.
- B. Single-Layer Application:
1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.
 2. On partitions/walls, apply gypsum panels horizontally (perpendicular to framing) unless otherwise indicated or required by fire-resistance-rated assembly, and minimize end joints.
 - a. Stagger abutting end joints not less than one framing member in alternate courses of panels.
 - b. At stairwells and other high walls, install panels horizontally unless otherwise indicated or required by fire-resistance-rated assembly.
 3. On Z-shaped furring members, apply gypsum panels vertically (parallel to framing) with no end joints. Locate edge joints over furring members.
 4. Fastening Methods: Apply gypsum panels to supports with steel drill screws.
- C. Multilayer Application:
1. On ceilings, apply gypsum board indicated for base layers before applying base layers on walls/partitions; apply face layers in same sequence. Apply base layers at right angles to framing members and offset face-layer joints one framing member, 16 inches (400 mm) minimum, from parallel base-layer joints, unless otherwise indicated or required by fire-resistance-rated assembly.

2. On partitions/walls, apply gypsum board indicated for base layers and face layers vertically (parallel to framing) with joints of base layers located over stud or furring member and face-layer joints offset at least one stud or furring member with base-layer joints unless otherwise indicated or required by fire-resistance-rated assembly. Stagger joints on opposite sides of partitions.
 3. On Z-shaped furring members, apply base layer vertically (parallel to framing) and face layer either vertically (parallel to framing) or horizontally (perpendicular to framing) with vertical joints offset at least one furring member. Locate edge joints of base layer over furring members.
 4. Fastening Methods: Fasten base layers and face layers separately to supports with screws.
- D. Laminating to Substrate: Where gypsum panels are indicated as directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's written instructions and temporarily brace or fasten gypsum panels until fastening adhesive has set.
- 3.4 INSTALLATION OF EXTERIOR GYPSUM PANELS FOR CEILINGS AND SOFFITS
- A. Apply panels perpendicular to supports, with end joints staggered and located over supports.
1. Install with 1/4-inch (6.4-mm) open space where panels abut other construction or structural penetrations.
 2. Fasten with corrosion-resistant screws.
- 3.5 INSTALLATION OF BACKING PANELS
- A. Glass-Mat, Water-Resistant Backing Panels: Comply with manufacturer's written installation instructions and install at non-wet locations indicated to receive tile or other indicated finish materials. Install with 1/4-inch (6.4-mm) gap where panels abut other construction or penetrations.
- B. Cementitious Backer Units: ANSI A108.11, at wet area locations indicated to receive tile or other indicated finish materials.
- C. Where backing panels abut other types of panels in same plane, shim surfaces to produce a uniform plane across panel surfaces.
- 3.6 INSTALLATION OF TRIM ACCESSORIES
- A. General: For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.
- B. Control Joints: Install control joints according to ASTM C 840, including compliance with ASTM 20.3.1 - 20.4 for control joint spacing, whether or not such joints are indicated on Drawings, in specific locations approved by Architect for visual effect and as follows.
1. Install at changes in backup material.
 2. Framed Openings (Both Sides of Partition):
 - a. Doors: Install above both jambs unless indicated or directed otherwise.
 - b. Glazed Openings: Install above and below both jambs unless indicated or directed otherwise.
 3. Install at other locations indicated on Drawings.

- C. Interior Trim: Install in the following locations:
 - 1. Cornerbead: Use at outside corners unless otherwise indicated.
 - 2. LC-Bead: Use at exposed panel edges.
 - 3. L-Bead: Use where indicated on Drawings.
 - 4. U-Bead: Use where indicated on Drawings.
- D. Exterior Trim: Install in the following locations:
 - 1. Cornerbead: Use at outside corners.
 - 2. LC-Bead: Use at exposed panel edges.
- E. Firestop Putty Pads: Install at power, audio/visual, data, light and similar boxes located in fire-rated partitions. Install in accordance with pad manufacturer's instructions.
- F. Acoustic Putty Pads: Install at power, audio/visual, data, light and similar boxes located in acoustic-rated partitions. Install in accordance with pad manufacturer's instructions.

3.7 FINISHING OF GYPSUM BOARD

- A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.
- B. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.
- C. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C840:
 - 1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
 - 2. Level 2: Where indicated on Drawings.
 - 3. Level 3: Where indicated on Drawings.
 - 4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
 - a. Primer and its application to surfaces are specified in Section 09 9123 "Interior Painting."
 - 5. Level 5: Where indicated on Drawings.
 - a. Primer and its application to surfaces are specified in Section 09 9123 "Interior Painting."
- D. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

3.8 PROTECTION

- A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.
- B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.
- C. Remove and replace panels that are wet, moisture damaged, and mold damaged.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.
2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

FOR REFERENCE ONLY

SECTION 09 3013 - CERAMIC TILING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Glazed wall tile.
 - 2. Setting material.
 - 3. Grout materials.
- B. Related Requirements:
 - 1. Section 09 2900 "Gypsum Board" for tile backing panels.

1.2 DEFINITIONS

- A. General: Definitions in ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.
- B. Face Size: Actual tile size, excluding spacer lugs.
- C. Module Size: Actual tile size plus joint width indicated.
- D. Wet Area: The term "wet area" refers to shower rooms and other areas with similar usages. It does not refer to toilet rooms and other similar areas where water on the floor is seldom encountered.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review requirements in ANSI A108.01 for substrates and for preparation by other trades.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show locations, plans, and elevations, of each type of tile and tile pattern. Show widths, details, and locations of movement joints in tile substrates and finished tile surfaces.
- C. Samples for Initial Selection: For tile, grout, and accessories involving color selection or shade variation.
- D. Samples for Verification:
 - 1. Full-size units of each type and composition of tile and for each color and finish required.
 - 2. Assembled samples mounted on a rigid panel, with grouted joints, for each type and composition of tile and for each color and finish required. Make samples at least 36 inches (900 mm) square, but not fewer than four tiles. Use grout of type and in color or colors approved for completed Work.
 - 3. Full-size units of each type of trim and accessory[**for each color and finish required**].

- E. Sustainable Design Submittals:
 1. Environmental Product Declaration: For each product.
 2. Health Product Declaration: For each product.
 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 4. Laboratory Test Reports: For composite wood products, indicating compliance with requirements for low-emitting materials.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.
 2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installer is a Five-Star member of the National Tile Contractors Association or a Trowel of Excellence member of the Tile Contractors' Association of America.
- B. Provide the following upon request:
 1. Qualification Data: For Installer.
 2. Master Grade Certificates: For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.
 3. Product Certificates: For each type of product, including product use classification.
 4. Product Test Reports:
 - a. Tile-setting and -grouting products.
 - b. Certified porcelain tile.
 - c. Slip-resistance test reports from qualified independent testing agency.
 5. Field Quality-Control Reports: Water test reports of membrane in wet areas.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.
- B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.
- C. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.
- D. Store liquid materials in unopened containers and protected from freezing.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Tile: Obtain tile of each type and color or finish from single source or producer.
 - 1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

2.2 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
 - 1. Provide tile complying with Standard Grade requirements unless otherwise indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.
- C. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.
- D. Factory-Applied Temporary Protective Coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by precoating with continuous film of petroleum paraffin wax, applied hot. Do not coat unexposed tile surfaces.

2.3 GLAZED WALL TILE

- A. Glazed Wall Tile Type (TL-01):
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Daltile; a brand of Dal-Tile Corporation.
 - 2. Basis-of-Design Products: As scheduled; refer to Finish Schedule.
 - 3. Module Size: Insert dimensions.
 - 4. Face Size Variation: Rectified.
 - 5. Thickness: 5/16 inch (8 mm).
 - 6. Tile Color and Pattern: As indicated by manufacturer's designations .
 - 7. Grout Color: As selected by Architect from manufacturer's full range .
 - 8. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:

- a. External Corners for Thinset Mortar Installations: Surface bullnose; same size as adjoining flat tile.

2.4 BACKING PANELS

- A. Backing Panels: Specified in Section 09 2900 "Gypsum Board."

2.5 CRACK ISOLATION MEMBRANES

- A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.12 for high performance and is recommended by manufacturer for application indicated. Include reinforcement and accessories recommended by manufacturer.
- B. Crack Isolation Membrane, Polyethylene Sheet: Polyethylene faced on both sides with polyester fabric.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Custom Building Products.
 - b. Laticrete International, Inc.
 - c. MAPEI Corporation.
 - d. Noble Company (The).
- C. Crack Isolation Membrane, Asphaltic Sheet: Self-adhering, modified-asphalt sheet with fabric reinforcement facing.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Boiardi Products Corporation; a QEP company.
 - b. Custom Building Products.
 - c. MAPEI Corporation.
 - d. National Applied Construction Products, Inc.
 - e. Sika Corporation; Flooring.
- D. Crack Isolation Membrane, Fluid Applied: Liquid-latex rubber or elastomeric polymer with continuous fabric reinforcement.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bostik; Arkema.
 - b. C-Cure.
 - c. Custom Building Products.
 - d. H.B. Fuller Construction Products Inc. / TEC.
 - e. Jamo Inc.
 - f. Laticrete International, Inc.
 - g. MAPEI Corporation.
 - h. Parex USA, Inc.
 - i. Siena Tile & Stone Installation Products; Omega Products International.
 - j. Sika Corporation.
 - k. Southern Grouts & Mortars, Inc.

2.6 SETTING MATERIALS

- A. Improved Modified Dry-Set Mortar (Thinset): ANSI A118.15.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ARDEX Americas.
 - b. Custom Building Products.
 - c. H.B. Fuller Construction Products Inc. / TEC.
 - d. Laticrete International, Inc.
 - e. MAPEI Corporation.
 - f. Parex USA, Inc.
 - g. Siena Tile & Stone Installation Products; Omega Products International.
2. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
3. For wall applications, provide mortar that complies with requirements for nonsagging mortar in addition to other requirements in ANSI A118.15.

2.7 GROUT MATERIALS

A. High-Performance Tile Grout: ANSI A118.7.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ARDEX Americas.
 - b. Bostik; Arkema.
 - c. Custom Building Products.
 - d. H.B. Fuller Construction Products Inc. / TEC.
 - e. Laticrete International, Inc.
 - f. MAPEI Corporation.
 - g. Parex USA, Inc.
 - h. Southern Grouts & Mortars, Inc.
 - i. Summitville Tiles, Inc.
2. Polymer Type:
 - a. Dry, redispersible form, prepackaged with other dry ingredients.

2.8 MISCELLANEOUS MATERIALS

- A. Trowelable Underlayment and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting and adhesive materials for installations indicated.
- B. Vapor-Retarder Membrane: Polyethylene sheeting, ASTM D4397, 4.0 mils (0.1 mm) thick.
- C. Metal Edge Trim: Profile designed for wall terminations and edge protection.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Blanke Corporation.
 - b. Custom Building Products.
 - c. Dural USA, Inc.
 - d. Profiline Corp.
 - e. Progress Profiles America Inc.
 - f. Schluter Systems L.P.
 2. Description: L-shaped .
 3. Terminations: End caps matching edge-protection profile.
 4. Material and Finish: Insert finish exposed-edge material.

- a. Color: Insert color.
- D. Temporary Protective Coating: Formulated to protect exposed surfaces of tile against adherence of mortar and grout; compatible with tile, mortar, and grout products and easily removable after grouting is completed without damaging grout or tile.
- E. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.
- F. Grout Sealer: Grout manufacturer's standard product for sealing grout joints that does not change color or appearance of grout.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
 - 2. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.
 - 3. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove coatings, including curing compounds or other coatings, that are incompatible with tile-setting materials.
- B. Where indicated, prepare substrates to receive waterproof membrane by applying a reinforced mortar bed that complies with ANSI A108.1 and is sloped 1/4 inch per foot (1:50) toward drains.
- C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.
- D. Substrate Flatness:
 - 1. For tile shorter than 15 inches (381 mm), confirm that structure or substrate is limited to variation of 1/4 inch in 10 ft. (6.4 mm in 3 m) from the required plane, and no more than 1/16 inch in 12 inches (1.5 mm in 300 mm) when measured from tile surface high points.

- E. Field-Applied Temporary Protective Coating: If indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, precoat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.3 INSTALLATION OF CERAMIC TILE SYSTEM

- A. Install waterproof membrane to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness that is bonded securely to substrate.
 - 1. Allow waterproof membrane to cure and verify by testing that it is watertight before installing tile or setting materials over it.
- B. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.
 - 1. Allow crack isolation membrane to cure before installing tile or setting materials over it.
- C. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.
 - 1. Add materials, water, and additives in accurate proportions.
 - 2. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.
- D. Install tile in accordance with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 series that are referenced in TCNA installation methods and specified in tile installation schedules, and apply to types of setting and grouting materials used.
 - 1. For the following installations, follow procedures in ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
 - a. Exterior tile floors and walls.
 - b. Tile floors in wet areas.
 - c. Tile swimming pool decks.
 - d. Tile floors in laundries.
 - e. Tile floors consisting of tiles 8 by 8 inches (200 by 200 mm) or larger.
 - f. Tile floors consisting of rib-backed tiles.
 - 2. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
 - 3. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
 - 4. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.
 - 5. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.
 - 6. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

- a. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets, so joints between sheets are not apparent in finished Work.
 - b. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.
 - c. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.
 7. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.
 8. Joint Widths: Install tile with joint widths indicated on Drawings, or if not indicated, as directed by Architect.
 - E. Movement Joints: Provide movement joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated on Drawings. Form joints during installation of setting materials, mortar beds, and tile. Keep joints free of dirt, debris, and setting materials prior to filling with sealants. Do not saw-cut joints after installing tiles.
 1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
 2. Prepare joints and apply sealants to comply with requirements in Section 07 9200 "Joint Sealants."
 3. Comply with requirements of the TCNA Handbook for Ceramic, Glass, and Stone Tile Installation; "EJ171 - Movement Joint Guidelines for Ceramic, Glass, and Stone":
 - a. Movement Joints: Maximum spacing of joints in interior tile shall be 20 to 25 feet in each direction. Fill joints with sealant matching grout color.
 - F. Metal Wall Trim: Install at locations indicated on Drawings.
 - G. Grout Sealer: Apply grout sealer to cementitious grout joints in accordance with manufacturer's written instructions. As soon as sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.
- 3.4 FIELD QUALITY CONTROL
- A. Nonconforming Work:
 1. Waterproof membrane will be considered defective if water level has dropped.
 2. Remove and replace defective components and retest.
- 3.5 ADJUSTING AND CLEANING
- A. Remove and replace tile that is damaged or that does not match adjoining tile. Provide new matching units, installed as specified and in a manner to eliminate evidence of replacement.
 - B. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.
 1. Remove grout residue from tile as soon as possible.
 2. Clean grout smears and haze from tile in accordance with tile and grout manufacturer's written instructions. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3.6 PROTECTION

- A. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.
- B. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.
- C. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.7 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE

- A. Interior Wall Installations, Metal Studs or Furring:
 - 1. TCNA W245 : Thinset mortar on glass-mat, water-resistant gypsum backer board.
 - a. Ceramic Tile Type: TL-01
 - b. Thinset Mortar: Modified dry-set mortar.
 - c. Grout: High-performance unsanded cement grout.

END OF SECTION

SECTION 09 5113 - ACOUSTICAL PANEL CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Acoustical panels.
 - 2. Metal suspension system.
 - 3. Metal edge moldings and trim.
- B. Products furnished, but not installed under this Section, include anchors, clips, and other ceiling attachment devices to be cast in concrete.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 01 3300 "Submittal Procedures".
- B. Product Data:
 - 1. Acoustical panels.
 - 2. Metal suspension system.
 - 3. Metal edge moldings and trim.
- C. Sustainable Design Submittals:
 - 1. Recycled Content: Provide manufacturer documentation for recycled content, indicating postconsumer and preconsumer recycled content.
 - 2. Product Certificates: For materials manufactured within 100 miles (160 km) of Project, indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include distance to Project and cost for each raw material.
 - 3. Environmental Product Declaration: For each product.
 - 4. Health Product Declaration: For each product.
 - 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - 6. Health Product Declaration (HPD): Provide documentation indicating that manufacturer has screened and publicly provided ingredient disclosure to 1000 ppm, and has developed an action plan to mitigate known hazards.
 - 7. Laboratory Test Reports: For ceiling products, indicating compliance with requirements for low-emitting materials.
- D. Shop Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension-system members.
 - 2. Structural members to which suspension systems will be attached.
 - 3. Method of attaching hangers to building structure.
 - a. Furnish layouts for cast-in-place anchors, clips, and other ceiling attachment devices whose installation is specified in other Sections.

4. Carrying channels or other supplemental support for hanger-wire attachment where conditions do not permit installation of hanger wires at required spacing.
5. Size and location of initial access modules for acoustical panels.
6. Items penetrating finished ceiling and ceiling-mounted items including the following:
 - a. Lighting fixtures.
 - b. Diffusers.
 - c. Grilles.
 - d. Speakers.
 - e. Sprinklers.
 - f. Access panels.
 - g. Perimeter moldings.
7. Show operation of hinged and sliding components covered by or adjacent to acoustical panels.
8. Minimum Drawing Scale: 1/4 inch = 1 foot (1:48) .

E. Samples: For each exposed product and for each color and texture specified, 6 inches (150 mm) in size.

F. Samples for Initial Selection: For components with factory-applied finishes.

G. Samples for Verification: For each component indicated and for each exposed finish required, prepared on Samples of sizes indicated below:

1. Acoustical Panels: Set of full-size Samples of each type, color, pattern, and texture.
2. Exposed Suspension-System Members, Moldings, and Trim: Set of 6-inch- (150-mm-) long Samples of each type, finish, and color.
3. Clips: Full-size hold-down clips.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance Data: For finishes to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Acoustical Ceiling Units: Full-size panels equal to 2 percent of quantity installed.
2. Suspension-System Components: Quantity of each exposed component equal to 2 percent of quantity installed.
3. Hold-Down Clips: Equal to 2 percent of quantity installed.
4. Impact Clips: Equal to 2 percent of quantity installed.

1.6 QUALITY ASSURANCE

A. Provide the following upon request:

1. Qualification Data: For testing agency.
2. Product Test Reports: For each acoustical panel ceiling, for tests performed by manufacturer and witnessed by a qualified testing agency.
3. Evaluation Reports: For each acoustical panel ceiling suspension system and anchor and fastener type, from ICC-ES.
4. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver acoustical panels, suspension-system components, and accessories to Project site and store them in a fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.
- B. Before installing acoustical panels, permit them to reach room temperature and a stabilized moisture content.

1.8 FIELD CONDITIONS

- A. Environmental Limitations: Do not install acoustical panel ceilings until spaces are enclosed and weathertight, wet-work in spaces is complete and dry, work above ceilings is complete, and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
 - 1. Pressurized Plenums: Operate ventilation system for not less than 48 hours before beginning acoustical panel ceiling installation.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Source Limitations for Ceiling System: Obtain each type of acoustical ceiling panel and its supporting suspension system from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Ceiling products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Spread Index: Class A in accordance with ASTM E1264.
 - 2. Smoke Developed Index: 450 or less.
- C. Fire-Resistance Ratings: Comply with ASTM E119; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Indicate design designations from UL or from the listings of another qualified testing agency.

2.3 ACOUSTICAL PANELS (ACT-01)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Armstrong Ceiling & Wall Solutions.
 - 2. Certainteed; SAINT-GOBAIN.
 - 3. Rockfon; ROCKWOOL International.
 - 4. USG Corporation.

- B. Basis-of-Design Products: As scheduled; refer to Finish Schedule.
- C. Acoustical Panel Standard: Provide manufacturer's standard panels in accordance with ASTM E1264 and designated by type, form, pattern, acoustical rating, and light reflectance unless otherwise indicated.
- D. Recycled Content: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 25 percent.
- E. Classification: Provide fire-resistance-rated panels as follows:
 - 1. Pattern: as indicated by manufacturer's designation .
- F. Color: As indicated in a schedule .
- G. Edge/Joint Detail: As indicated by manufacturer's designation .
- H. Thickness:
 - 1. As indicated in a schedule .
- I. Modular Size: As indicated in a schedule .
- J. Antimicrobial Treatment: Manufacturer's standard broad spectrum, antimicrobial formulation that inhibits fungus, mold, mildew, and gram-positive and gram-negative bacteria and showing no mold, mildew, or bacterial growth when tested in accordance with ASTM D3273, ASTM D3274, or ASTM G21 and evaluated in accordance with ASTM D3274 or ASTM G21.

2.4 METAL SUSPENSION SYSTEM (ACT-01)

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Armstrong Ceiling & Wall Solutions.
 - 2. Certainteed; SAINT-GOBAIN.
 - 3. Rockfon; ROCKWOOL International.
 - 4. USG Corporation.
- B. Wide-Face, Capped, Double-Web, Steel Suspension System: Main and cross runners roll formed from cold-rolled steel sheet; prepainted, electrolytically zinc coated, or hot-dip galvanized, G30 (Z90) coating designation; with prefinished 15/16-inch- (24-mm-) wide metal caps on flanges.
 - 1. Fire Rating: As indicated on Drawings.
 - 2. Structural Classification: Heavy-duty system.
 - 3. End Condition of Cross Runners: Override (stepped) type.
 - 4. Face Design: Flat, flush.
 - 5. Cap Material: Cold-rolled steel .
 - 6. Cap Finish: Painted to match color indicated by manufacturer's designation .

2.5 ACCESSORIES

- A. Attachment Devices: Size for five times the design load indicated in ASTM C635/C635M, Table 1, "Direct Hung," unless otherwise indicated. Comply with seismic design requirements.

1. Anchors in Concrete: Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to five times that imposed by ceiling construction, as determined by testing in accordance with ASTM E488/E488M or ASTM E1512 as applicable, conducted by a qualified testing and inspecting agency.
 - a. Type: Postinstalled expansion anchors.
 - b. Corrosion Protection, Carbon Steel: Components zinc plated in accordance with ASTM B633, Class SC 1 (mild) service condition.
 2. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing in accordance with ASTM E1190, conducted by a qualified testing and inspecting agency.
- B. Wire Hangers, Braces, and Ties: Provide wires as follows:
1. Zinc-Coated, Carbon-Steel Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper.
 2. Size: Wire diameter sufficient for its stress at three times hanger design load (ASTM C635/C635M, Table 1, "Direct Hung") will be less than yield stress of wire, but not less than 0.135-inch- (3.5-mm-) diameter wire.
 3. Size:
 - a. Hanger Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.
 - b. Seismic Bracing Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.
 - c. Slack Safety Wire Size: 0.106 inch (No. 12-gauge) (2.68 mm) diameter wire.
- C. Hanger Rods: Mild steel, zinc coated or protected with rust-inhibitive paint.
- D. Flat Hangers: Mild steel, zinc coated or protected with rust-inhibitive paint.
- E. Angle Hangers: Angles with legs not less than 7/8 inch (22 mm) wide; formed with 0.04-inch- (1-mm-) thick, galvanized-steel sheet complying with ASTM A653/A653M, G90 (Z275) coating designation; with bolted connections and 5/16-inch- (8-mm-) diameter bolts.
- F. Hold-Down Clips: Manufacturer's standard hold-down.
- G. Stabilizer Clips: Manufacturer's standard stabilizer clips designed for use with large format ceiling panels.
- 2.6 METAL EDGE MOLDINGS AND TRIM <Insert drawing designation>
- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Armstrong Ceiling & Wall Solutions.
 2. Certainteed; SAINT-GOBAIN.
 3. Rockfon; ROCKWOOL International.
 4. USG Corporation.

- B. Roll-Formed, Sheet-Metal Edge Moldings: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that comply with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for exposed flanges of suspension-system runners.
 - 1. Edge moldings to fit acoustical panel edge details and suspension systems indicated and match width and configuration of exposed runners unless otherwise indicated.
 - a. Provide 2-inch (50 mm) wide wall angles.
 - 2. For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
 - 3. For circular penetrations of ceiling, provide edge moldings fabricated to diameter required to fit penetration exactly.

2.7 ACOUSTICAL SEALANT

- A. Acoustical Sealant: As specified in Section 07 9219 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, including structural framing to which acoustical panel ceilings attach or abut, with Installer present, for compliance with requirements specified in this and other Sections that affect ceiling installation and anchorage and with requirements for installation tolerances and other conditions affecting performance of acoustical panel ceilings.
- B. Examine acoustical panels before installation. Reject acoustical panels that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Measure each ceiling area and establish layout of acoustical panels to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width panels at borders unless otherwise indicated, and comply with layout shown on reflected ceiling plans.
- B. Layout openings for penetrations centered on the penetrating items.

3.3 INSTALLATION OF ACOUSTICAL PANEL CEILINGS

- A. Install acoustical panel ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.
 - 1. Fire-Rated Assembly: Install fire-rated ceiling systems in accordance with tested fire-rated design.
- B. Suspend ceiling hangers from building's structural members and as follows:
 - 1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structure or of ceiling suspension system.

2. Splay hangers only where required and, if permitted with fire-resistance-rated ceilings, to miss obstructions; offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 3. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension-system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices.
 4. Secure wire hangers to ceiling-suspension members and to supports above with a minimum of three tight turns. Connect hangers directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate and that will not deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
 5. Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for both the structure to which hangers are attached and the type of hanger involved. Install hangers in a manner that will not cause them to deteriorate or fail due to age, corrosion, or elevated temperatures.
 6. Do not support ceilings directly from permanent metal forms or floor deck. Fasten hangers to cast-in-place hanger inserts, postinstalled mechanical or adhesive anchors, or power-actuated fasteners that extend through forms into concrete.
 7. When steel framing does not permit installation of hanger wires at spacing required, install carrying channels or other supplemental support for attachment of hanger wires.
 8. Do not attach hangers to steel deck tabs.
 9. Do not attach hangers to steel roof deck. Attach hangers to structural members.
 10. Space hangers not more than 48 inches (1200 mm) o.c. along each member supported directly from hangers unless otherwise indicated; provide hangers not more than 8 inches (200 mm) from ends of each member.
 11. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.
- C. Secure bracing wires to ceiling suspension members and to supports with a minimum of four tight turns. Suspend bracing from building's structural members as required for hangers, without attaching to permanent metal forms, steel deck, or steel deck tabs. Fasten bracing wires into concrete with cast-in-place or postinstalled anchors.
- D. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical panels.
1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
 2. Screw attach moldings to substrate at intervals not more than 16 inches (400 mm) o.c. and not more than 3 inches (75 mm) from ends. Miter corners accurately and connect securely.
 3. Do not use exposed fasteners, including pop rivets, on moldings and trim.
- E. Install suspension-system runners so they are square and securely interlocked with one another. Remove and replace dented, bent, or kinked members.
- F. Install acoustical panels with undamaged edges and fit accurately into suspension-system runners and edge moldings. Scribe and cut panels at borders and penetrations to provide precise fit.
1. Arrange directionally patterned acoustical panels as follows:
 - a. As indicated on reflected ceiling plans.

- b. Install panels with pattern running in one direction parallel to [long] [short] axis of space.
- c. Install panels in a basket-weave pattern.
- 2. For square-edged panels, install panels with edges fully hidden from view by flanges of suspension-system runners and moldings.
- 3. For reveal-edged panels on suspension-system runners, install panels with bottom of reveal in firm contact with top surface of runner flanges.
- 4. For reveal-edged panels on suspension-system members with box-shaped flanges, install panels with reveal surfaces in firm contact with suspension-system surfaces and panel faces flush with bottom face of runners.
- 5. Paint cut edges of panel remaining exposed after installation; match color of exposed panel surfaces using coating recommended in writing for this purpose by acoustical panel manufacturer.
- 6. Install hold-down clips in areas indicated; space in accordance with panel manufacturer's written instructions unless otherwise indicated.
 - a. Hold-Down Clips: Space o.c. on all cross runners.
- 7. Install stabilizer clips in areas receiving ceiling panels with a dimension of 48 inches or more on one or more sides. Install in accordance with manufacturer's instructions, at ceiling panel mid-points. At ceiling panels with a dimension greater than 48 inches, provide stabilizer clips at 24 inches o.c. maximum.
- 8. Install clean-room gasket system in areas indicated, sealing each panel and fixture as recommended by panel manufacturer's written instructions.
- 9. Protect lighting fixtures and air ducts in accordance with requirements indicated for fire-resistance-rated assembly.

3.4 ERECTION TOLERANCES

- A. Suspended Ceilings: Install main and cross runners level to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.
- B. Moldings and Trim: Install moldings and trim to substrate and level with ceiling suspension system to a tolerance of 1/8 inch in 12 feet (3 mm in 3.6 m), non-cumulative.

3.5 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Periodic inspection during the installation of suspended ceiling grids in accordance with ASCE/SEI 7.
- B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- C. Perform the following tests and inspections of completed installations of acoustical panel ceiling hangers and anchors and fasteners in successive stages and when installation of ceiling suspension systems on each floor has reached 20 percent completion, but no panels have been installed. Do not proceed with installations of acoustical panel ceiling hangers for the next area until test results for previously completed installations of acoustical panel ceiling hangers show compliance with requirements.

1. Within each test area, testing agency will select one of every 10 power-actuated fasteners and postinstalled anchors used to attach hangers to concrete and will test them for 200 lbf (890 N) of tension; it will also select one of every two postinstalled anchors used to attach bracing wires to concrete and will test them for 440 lbf (1957 N) of tension.
 2. When testing discovers fasteners and anchors that do not comply with requirements, testing agency will test those anchors not previously tested until 20 pass consecutively and then will resume initial testing frequency.
- D. Acoustical panel ceiling hangers, anchors, and fasteners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- 3.6 CLEANING
- A. Clean exposed surfaces of acoustical panel ceilings, including trim, edge moldings, and suspension-system members. Comply with manufacturer's written instructions for cleaning and touchup of minor finish damage.
- B. Remove and replace ceiling components that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

END OF SECTION

SECTION 09 6723 - RESINOUS FLOORING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 1. Resinous flooring.
 2. Integral cove base accessories.
- B. Related Sections:
 1. Section 07 1800 "Traffic Coatings" for vehicular-traffic-bearing, elastomeric flooring systems.
 2. Section 09 6623 "Resinous Matrix Terrazzo Flooring" for thinset, epoxy-matrix terrazzo.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 1. Review manufacturer's written instructions for substrate preparation and environmental conditions affecting resinous flooring installation.
 2. Review details of integral cove bases.
 3. Review manufacturer's written instructions for installing resinous flooring systems.
 4. Review protection measures for adjacent construction and installed flooring, floor drainage requirements, curbs, base details, and so forth.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include manufacturer's technical data, installation instructions, and recommendations for each resinous flooring component required.
- B. Sustainable Design Submittals:
 1. Environmental Product Declaration: For each product.
 2. Health Product Declaration: For each product.
 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 4. Multi-Attribute Optimization: For each product, provide documentation of third-party certification, indicating impact reduction in global warming potential, depletion of stratospheric ozone layer, acidification of land and water sources, eutrophication, and/or formation of tropospheric ozone.
 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 6. Supply Chain Optimization: For each product, provide documentation demonstrating that manufacturer practices comply with supply chain optimization requirements.
 7. Laboratory Test Reports: For flooring products, indicating compliance with requirements for low-emitting materials.
 8. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
- C. Samples: For each resinous floor system required and for each color and texture specified, 6 inches (150 mm) square in size, applied to a rigid backing by Installer for this Project.
- D. Samples for Initial Selection: For each type of exposed finish required.

- E. Samples for Verification: For each resinous flooring system required and for each color and texture specified, 6 inches (150 mm) square, applied to a rigid backing by Installer for this Project.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For resinous flooring to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
 - 1. Engage an installer who is certified in writing by resinous flooring manufacturer as qualified to apply resinous flooring systems indicated.
- B. Mockups: Build mockups to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.
 - 1. Apply full-thickness mockups on 96-inch- (2400-mm-) square floor area indicated on Drawings.
 - a. Include 96-inch (2400-mm) length of integral cove base with inside and outside corner.
 - 2. Simulate finished lighting conditions for Architect's review of mockups.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- C. Provide the following upon request:
 - 1. Qualification Data: For Installer.
 - 2. Material Certificates: For each resinous flooring component.
 - 3. Material Test Reports: For each resinous flooring system, by a qualified testing agency.
 - 4. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver materials in original packages and containers, with seals unbroken, bearing manufacturer's labels indicating brand name and directions for storage and mixing with other components.

1.7 FIELD CONDITIONS

- A. Environmental Limitations: Comply with resinous flooring manufacturer's written instructions for substrate temperature, ambient temperature, moisture, ventilation, and other conditions affecting resinous flooring installation.
- B. Lighting: Provide permanent lighting or, if permanent lighting is not in place, simulate permanent lighting conditions during resinous flooring installation.

- C. Close spaces to traffic during resinous flooring installation and for 24 hours after installation unless manufacturer recommends a longer period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Flooring products shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Flammability: Self-extinguishing in accordance with ASTM D635.

2.2 RESINOUS FLOORING (FL-01)

- A. Resinous Flooring System: Abrasion-, impact-, and chemical-resistant, aggregate-filled, resin-based monolithic floor surfacing designed to produce a seamless floor[**and integral cove base**].
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Stonhard, Inc. - STONGARD MR
 - 2. Basis-of-Design Products: As indicated on Drawings.
- B. Source Limitations: Obtain primary resinous flooring materials, including primers, resins, hardening agents, grouting coats, and topcoats, from single source from single manufacturer. Obtain secondary materials, including patching and fill material, joint sealant, and repair materials, of type and from manufacturer recommended in writing by manufacturer of primary materials.
- C. System Characteristics:
 - 1. Color and Pattern: As indicated by manufacturer's product designation .
 - 2. Wearing Surface: Manufacturer's standard wearing surface .
 - 3. Overall System Thickness: 40 mils (1.0 mm).
- D. Primer: Type recommended in writing by resinous flooring manufacturer for substrate and resinous flooring system indicated.
- E. Waterproofing Membrane: Type recommended in writing by resinous flooring manufacturer for substrate and resinous flooring system indicated.
- F. Reinforcing Membrane: Flexible resin formulation that is recommended in writing by resinous flooring manufacturer for substrate and resinous flooring system indicated and that inhibits substrate cracks from reflecting through resinous flooring.
- G. Patching and Fill Material: Resinous product of or approved by resinous flooring manufacturer and recommended in writing by manufacturer for installation indicated.
- H. Body Coats:
 - 1. Resin: Epoxy Urethane.

2. Formulation Description: High solids .
3. Type: Pigmented .
4. Installation Method: Self-leveling slurry with broadcast aggregates .
5. Number of Coats: Two .
6. Thickness of Coats: 8 mils (0.2 mm) 1/16 inch (1.6 mm) 1/8 inch (3.2 mm).
7. Aggregates: Manufacturer's standard .

I. Grout Coat:

1. Resin: Epoxy Urethane .
2. Formulation Description: High solids.
3. Type: Clear Pigmented.
4. Thickness of Coat: 8 mils (0.2 mm) 1/16 inch (1.6 mm) 1/8 inch (3.2 mm).

J. Topcoats: Sealing or finish coats.

1. Resin: Epoxy Urethane .
2. Formulation Description: [100 percent solids] [High solids] [Water based] <Insert requirements>.
3. Type: Clear.
4. Number of Coats: Two.
5. Thickness of Coats: 8 mils (0.2 mm) 1/16 inch (1.6 mm) 1/8 inch (3.2 mm).
6. Finish: Matte.

2.3 INTEGRAL COVE BASE ACCESSORIES

A. Precast, Integral Cove Base: Impact-resistant, polymer-resin, cove base moldings with a grit profile to promote adhesion of resinous flooring and recommended in writing by resinous flooring manufacturer.

1. Radius Cove Base: 6-inch- (152-mm-) high base molding that provides approximately 1-inch (25-mm) radius cove at floor-to-wall joint; for adhesive installation as substrate for resinous flooring system to form an integral cove base.

B. Installation Adhesive: As recommended in writing by accessory manufacturer.

1. Adhesives: Use adhesives that meet the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

1. Verify that finishes of substrates comply with tolerances and other requirements specified in other Sections and that substrates are free of cracks, ridges, depressions, scale, and foreign deposits that might interfere with adhesion of resinous flooring systems.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Prepare and clean substrates in accordance with resinous flooring manufacturer's written instructions for substrate indicated to ensure adhesion.
- B. Concrete Substrates: Provide sound concrete surfaces free of laitance, glaze, efflorescence, curing compounds, form-release agents, dust, dirt, grease, oil, and other contaminants incompatible with resinous flooring.
 - 1. Roughen concrete substrates as follows:
 - a. Shot-blast surfaces with an apparatus that abrades the concrete surface, contains the dispensed shot within the apparatus, and recirculates the shot by vacuum pickup.
 - b. Comply with requirements in SSPC-SP 13/NACE No. 6, with a Concrete Surface Profile of 3 or greater in accordance with ICRI Technical Guideline No. 310.2R, unless manufacturer's written instructions are more stringent.
 - 2. Repair damaged and deteriorated concrete in accordance with resinous flooring manufacturer's written instructions.
 - 3. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
 - a. Anhydrous Calcium Chloride Test: ASTM F1869. Proceed with installation only after substrates have maximum moisture-vapor-emission rate of 3 lb of water/1000 sq. ft. (1.36 kg of water/92.9 sq. m) in 24 hours.
 - b. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.
 - c. If water moisture tests exceed stated limits, apply vapor retarder for moisture vapor emission control as specified in Section 09 0561.13.
 - 4. Alkalinity and Adhesion Testing: Perform tests recommended in writing by resinous flooring manufacturer. Proceed with installation only after substrate alkalinity is not less than 6 or more than 8 pH unless otherwise recommended in writing by flooring manufacturer.
- C. Patching and Filling: Use patching and fill material to fill holes and depressions in substrates in accordance with manufacturer's written instructions.
 - 1. Control Joint Treatment: Treat control joints and other nonmoving substrate cracks to prevent cracks from reflecting through resinous flooring in accordance with manufacturer's written instructions.
- D. Resinous Materials: Mix components and prepare materials in accordance with resinous flooring manufacturer's written instructions.

3.3 INSTALLATION

- A. Apply components of resinous flooring system in accordance with manufacturer's written instructions to produce a uniform, monolithic wearing surface of thickness specified.
 - 1. Coordinate installation of components to provide optimum adhesion of resinous flooring system to substrate, and optimum intercoat adhesion.
 - 2. Cure resinous flooring components in accordance with manufacturer's written instructions. Prevent contamination during installation and curing processes.

3. Expansion and Isolation Joint Treatment: At substrate expansion and isolation joints, comply with resinous flooring manufacturer's written instructions.
- B. Primer: Apply primer over prepared substrate at spreading rate recommended in writing by manufacturer.
- C. Waterproofing Membrane: Apply waterproofing membrane where indicated on Drawings, in thickness recommended in writing by manufacturer.
 1. Apply waterproofing membrane to integral cove base substrates.
- D. Reinforcing Membrane: Apply reinforcing membrane to Insert requirements.
- E. Integral Cove Base Accessories: Adhesively install precast accessories before applying flooring coats and in accordance with manufacturer's written instructions.
- F. Self-Leveling Body Coats: Apply self-leveling slurry body coats in thickness specified for flooring system.
 1. Aggregates: Broadcast aggregates at rate recommended in writing by manufacturer. After resin is cured, remove excess aggregates to provide surface texture indicated.
- G. Grout Coat: Apply grout coat to fill voids in surface of final body coat.
- H. Topcoats: Apply topcoats in number indicated for flooring system specified, at spreading rates recommended in writing by manufacturer, and to produce wearing surface specified.

3.4 FIELD QUALITY CONTROL

- A. Material Sampling: Owner may, at any time and any number of times during resinous flooring installation, require material samples for testing for compliance with requirements.
 1. Owner will engage an independent testing agency to take samples of materials being used. Material samples will be taken, identified, sealed, and certified in presence of Contractor.
 2. Testing agency will test samples for compliance with requirements, using applicable referenced testing procedures or, if not referenced, using testing procedures listed in manufacturer's product data.
 3. If test results show applied materials do not comply with specified requirements, pay for testing, remove noncomplying materials, prepare surfaces coated with unacceptable materials, and reinstall flooring materials to comply with requirements.
- B. Core Sampling: At Owner's direction and at locations designated by Owner, take one core sample per 1000 sq. ft. (92.9 sq. m) of resinous flooring, or portion of, to verify thickness. For each sample that fails to comply with requirements, take two additional samples. Repair damage caused by coring. Correct deficiencies in installed flooring as indicated by testing.

3.5 PROTECTION

- A. Protect resinous flooring from damage and wear during the remainder of construction period. Use protective methods and materials, including temporary covering, recommended in writing by resinous flooring manufacturer.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 09 9123 - INTERIOR PAINTING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes surface preparation and the application of paint systems on the following interior substrates:
 - 1. Gypsum board.
- B. Related Requirements:
 - 1. Section 09 9600 "High-Performance Coatings" for tile-like coatings.

1.2 DEFINITIONS

- A. MPI Gloss Level 3 (Eggshell Finish): 10 to 25 units at 60 degrees and 10 to 35 units at 85 degrees, according to ASTM D523.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include preparation requirements and application instructions.
 - 1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 2. Indicate VOC content.
- B. Sustainable Design Submittals:
 - 1. Product Data: For paints and coatings, indicating VOC content.
 - 2. Laboratory Test Reports: For paints and coatings, indicating compliance with requirements for low-emitting materials.
 - 3. Environmental Product Declaration: For each product.
 - 4. Health Product Declaration: For each product.
 - 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - 6. Manufacturer Inventory: For each product, provide manufacturer's manifest of ingredients.
- C. Samples for Initial Selection: For each type of topcoat product.
- D. Samples for Verification: For each type of paint system and in each color and gloss of topcoat.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 - 2. Apply coats on Samples in steps to show each coat required for system.
 - 3. Label each coat of each Sample.
 - 4. Label each Sample for location and application area.
- E. Product List: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Paint: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.5 QUALITY ASSURANCE

- A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 1. Architect will select one surface to represent surfaces and conditions for application of each paint system.
 - a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
 - b. Other Items: Architect will designate items or areas required.
 2. Final approval of color selections will be based on mockups.
 - a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 1. Maintain containers in clean condition, free of foreign materials and residue.
 2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

- A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply paints when relative humidity exceeds 85 percent; at temperatures of less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Behr Paint Company; Behr Process Corporation.
 2. Benjamin Moore & Co.
 3. Dunn-Edwards Corporation (a Nippon Paint Holdings Co. Ltd. company).
 4. PPG Paints.
 5. Pratt & Lambert.
 6. Sherwin-Williams Company (The).

2.2 PAINT, GENERAL

- A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products List."
 - 1. Provide products from manufacturer's premium or professional product line.
- B. Material Compatibility:
 - 1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.
- C. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 - 1. Nonflat Paints and Coatings: 50 g/L.
 - 2. Primers, Sealers, and Undercoaters: 100 g/L.
- D. Low-Emitting Materials: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- E. Colors: As indicated in finish schedule.
 - 1. Items Not Included in Finish Schedule: As selected by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.
- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - 1. Gypsum Board: 12 percent.
- C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.
- E. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and paint systems indicated.

- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems indicated.

3.3 INSTALLATION

- A. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
 - 1. Use applicators and techniques suited for paint and substrate indicated.
 - 2. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.
 - 3. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - 4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 - 5. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
 - 6. Paint latex sealants color as directed by Architect.
- B. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.
- C. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- D. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:
 - 1. Paint the following work where exposed in occupied spaces:
 - a. Equipment, including panelboards.
 - b. Uninsulated metal piping.
 - c. Uninsulated plastic piping.
 - d. Pipe hangers and supports.
 - e. Metal conduit.
 - f. Plastic conduit.
 - g. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.
 - h. Other items as directed by Architect.
 - 2. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

3.4 FIRE-RATED AND SMOKE CONTAINMENT ASSEMBLIES

- A. Fire walls, fire barriers, fire partitions, smoke barriers and smoke partitions or any other wall required to have protected openings or penetrations shall be effectively and permanently identified with signs or stenciling. Such identification shall:
 - 1. Be located in accessible concealed floor, floor-ceiling or attic spaces; and
 - 2. Be located within 15 feet of each end of each wall and repeated at intervals not exceeding 30 feet measured horizontally along both sides of the wall or partition; and
 - 3. Include lettering not less than 3 inches in height, incorporating the suggested wording: "FIRE AND/OR SMOKE BARRIER-PROTECT ALL OPENINGS" or other wording approved or required by AHJ (Authority Having Jurisdiction).
 - 4. Apply a minimum one-inch wide bright red horizontal line, both sides of wall, interrupted for approved text, at the required interval.

3.5 FIELD QUALITY CONTROL

- A. Dry-Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry-film thickness.
 - 1. Contractor shall touch up and restore painted surfaces damaged by testing.
 - 2. If test results show that dry-film thickness of applied paint does not comply with paint manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry-film thickness that complies with paint manufacturer's written recommendations.

3.6 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

3.7 INTERIOR PAINTING SCHEDULE

- A. Gypsum Board Substrates: (P-01)
 - 1. Institutional Low-Odor/VOC Latex System, MPI INT 9.2M:
 - a. Prime Coat: Primer sealer, interior, institutional low odor/VOC, MPI #149.
 - b. Intermediate Coat: Latex, interior, institutional low odor/VOC, matching topcoat.
 - c. Topcoat: Latex, interior, institutional low odor/VOC, eggshell (MPI Gloss Level 3), MPI #145.

END OF SECTION

SECTION 09 9600 - HIGH-PERFORMANCE COATINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes surface preparation and the application of high-performance coating systems
 - 1. Interior Substrates:
 - a. Concrete, vertical and horizontal surfaces.
 - b. Cement board.
 - c. Concrete masonry units (CMUs).
 - d. Gypsum board.
- B. Related Requirements:
 - 1. Section 09 9123 "Interior Painting" for general field painting.

1.2 DEFINITIONS

- A. MPI Gloss Level 5 (Semi-Gloss Finish): 35 to 70 units at 60 degrees, according to ASTM D 523.
- B. MPI Gloss Level 6 (Gloss Finish): 70 to 85 units at 60 degrees, according to ASTM D 523.
- C. MPI Gloss Level 7 (High-Gloss Finish): More than 85 units at 60 degrees, according to ASTM D 523.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, include preparation requirements and application instructions.
 - 1. Include printout of current "MPI Approved Products List" for each product category specified, with the proposed product highlighted.
 - 2. Indicate VOC content.
- B. Sustainable Design Submittals:
 - 1. Product Data: For paints and coatings, indicating VOC content.
- C. Samples for Initial Selection: For each type of topcoat product indicated.
- D. Samples for Verification: For each type of coating system and each color and gloss of topcoat indicated.
 - 1. Submit Samples on rigid backing, 8 inches (200 mm) square.
 - 2. Apply coats on Samples in steps to show each coat required for system.
 - 3. Label each coat of each Sample.
 - 4. Label each Sample for location and application area.
- E. Product List: Cross-reference to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules. Include color designations.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Coatings: 5 percent, but not less than 1 gal. (3.8 L) of each material and color applied.

1.5 QUALITY ASSURANCE

- A. Mockups: Apply mockups of each coating system indicated to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 - 1. Architect will select one surface to represent surfaces and conditions for application of each coating system.
 - a. Wall and Ceiling Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
 - b. Other Items: Architect will designate items or areas required.
 - 2. Final approval of color selections will be based on mockups.
 - a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).
 - 1. Maintain containers in clean condition, free of foreign materials and residue.
 - 2. Remove rags and waste from storage areas daily.

1.7 FIELD CONDITIONS

- A. Apply coatings only when temperature of surfaces to be coated and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).
- B. Do not apply coatings when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.
- C. Do not apply exterior coatings in snow, rain, fog, or mist.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: (P-02, P-03) Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. STONHARD - Stoneglaze VSR
 - 2. Tnemec Company, Inc.

2.2 HIGH-PERFORMANCE COATINGS, GENERAL

- A. MPI Standards: Products shall comply with MPI standards indicated and shall be listed in its "MPI Approved Products Lists."
 - 1. Provide products from manufacturer's premium or professional product line.
- B. Material Compatibility:
 - 1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
 - 2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.
 - 3. Products shall be of same manufacturer for each coat in a coating system.
- C. VOC Content: For field applications that are inside the weatherproofing system, paints and coatings shall comply with VOC content limits of authorities having jurisdiction and the following VOC content limits:
 - 1. Nonflat Paints and Coatings: 50 g/L.
 - 2. Primers, Sealers, and Undercoaters: 100 g/L.
- D. Low-Emitting Materials: For field applications that are inside the weatherproofing system, 90 percent of paints and coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- E. Colors: As indicated in color schedule .

2.3 SOURCE QUALITY CONTROL

- A. Testing of Coating Materials: Owner reserves the right to invoke the following procedure:
 - 1. Owner will engage the services of a qualified testing agency to sample coating materials. Contractor will be notified in advance and may be present when samples are taken. If coating materials have already been delivered to Project site, samples may be taken at Project site. Samples will be identified, sealed, and certified by testing agency.
 - 2. Testing agency will perform tests for compliance with product requirements.
 - 3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with product requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

- B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
 - 1. Concrete: 12 percent.
 - 2. Fiber-Cement Board: 12 percent.
 - 3. Masonry (Clay and CMUs): 12 percent.
 - 4. Gypsum Board: 12 percent.
- C. Gypsum Board Substrates: Verify that finishing compound is sanded smooth.
- D. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.
- E. Proceed with coating application only after unsatisfactory conditions have been corrected.
 - 1. Application of coating indicates acceptance of surfaces and conditions.

3.2 PREPARATION

- A. Comply with manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual" applicable to substrates and coating systems indicated.
- B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - 1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
- C. Clean substrates of substances that could impair bond of coatings, including dust, dirt, oil, grease, and incompatible paints and encapsulants.
 - 1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce coating systems indicated.
- D. Concrete Substrates: Remove release agents, curing compounds, efflorescence, and chalk. Do not coat surfaces if moisture content or alkalinity of surfaces to be coated exceeds that permitted in manufacturer's written instructions.
 - 1. Clean surfaces with pressurized water. Use pressure range of 1500 to 4000 psi (10 350 to 27 580 kPa) at 6 to 12 inches (150 to 300 mm).
 - 2. Abrasive blast clean surfaces to comply with SSPC-SP 7/NACE No. 4.
- E. Masonry Substrates: Remove efflorescence and chalk. Do not coat surfaces if moisture content, alkalinity of surfaces, or alkalinity of mortar joints exceeds that permitted in manufacturer's written instructions.
 - 1. Clean surfaces with pressurized water. Use pressure range of 1500 to 4000 psi (10 350 to 27 580 kPa) at 6 to 12 inches (150 to 300 mm).

3.3 APPLICATION

- A. Apply high-performance coatings according to manufacturer's written instructions and recommendations in "MPI Architectural Painting Specification Manual."
 - 1. Use applicators and techniques suited for coating and substrate indicated.

2. Coat surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, coat surfaces behind permanently fixed equipment or furniture with prime coat only.
 3. Coat backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 4. Do not apply coatings over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
- B. Tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of the same material are to be applied. Tint undercoats to match color of finish coat, but provide sufficient difference in shade of undercoats to distinguish each separate coat.
 - C. If undercoats or other conditions show through final coat, apply additional coats until cured film has a uniform coating finish, color, and appearance.
 - D. Apply coatings to produce surface films without cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Produce sharp glass lines and color breaks.

3.4 FIELD QUALITY CONTROL

- A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test coatings for dry film thickness.
 1. Contractor shall touch up and restore coated surfaces damaged by testing.
 2. If test results show that dry film thickness of applied coating does not comply with coating manufacturer's written recommendations, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with coating manufacturer's written recommendations.

3.5 CLEANING AND PROTECTION

- A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
- B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
- C. Protect work of other trades against damage from coating operation. Correct damage to work of other trades by cleaning, repairing, replacing, and recoating, as approved by Architect, and leave in an undamaged condition.
- D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

END OF SECTION

SECTION 10 2800 - TOILET, BATH, AND LAUNDRY ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Public-use washroom accessories.
 - 2. Underlavatory guards.
- B. Related Requirements:
 - 1. Section 09 3013 "Ceramic Tiling" for ceramic toilet and bath accessories.

1.2 COORDINATION

- A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.
- B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.3 ACTION SUBMITTALS

- A. Product Data Submittals: For each product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.
 - 3. Include electrical characteristics.
- B. Samples: For each exposed product and for each finish specified, full size.
 - 1. Approved full-size Samples will be returned and may be used in the Work.
- C. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.
 - 1. Identify locations using room designations indicated.
 - 2. Identify accessories using designations indicated.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For accessories to include in maintenance manuals.

1.5 WARRANTY

- A. Manufacturer's Special Warranty for Mirrors: Manufacturer agrees to repair or replace mirrors that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, visible silver spoilage defects.
 - 2. Warranty Period: 15 years from date of Substantial Completion.

- B. Manufacturer's Special Warranty for Toilet-Compartment Occupancy-Indicator Systems: Manufacturer agrees to repair or replace toilet-compartment occupancy-indicator systems that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Design accessories and fasteners to comply with the following requirements:
 - 1. Grab Bars: Installed units are able to resist 250 lbf (1112 N) concentrated load applied in any direction and at any point.

2.2 PUBLIC-USE WASHROOM ACCESSORIES

- A. Source Limitations: Obtain public-use washroom accessories from single source from single manufacturer.
- B. Combination Toilet Tissue Dispenser (TA-06):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - 2. Description: Combination unit with double-roll toilet tissue dispenser and the following:
 - a. Removable sanitary-napkin waste receptacle with self-closing, disposal-opening cover.
 - b. Seat-cover dispenser with minimum capacity of 500 single or half-fold seat covers.
 - 3. Mounting: Recessed.
 - 4. Toilet Tissue Dispenser Capacity: 4-1/2- or 5-inch- (114- or 127-mm-) diameter tissue rolls.
 - 5. Toilet Tissue Dispenser Operation: Noncontrol delivery with theft-resistant spindles.
 - 6. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
 - 7. Lockset: Tumbler type.
- C. Combination Towel (Roll) Dispenser/Waste Receptacle (TA-05):
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
 - 2. Description: Combination unit for dispensing preset length of roll paper towels, with removable waste receptacle.
 - 3. Towel Mechanism: Lever.
 - 4. Mounting: Recessed.
 - 5. Minimum Towel-Dispenser Capacity: 8-inch- (203-mm-) wide, 800-foot- (244-m-) long roll.
 - 6. Minimum Waste Receptacle Capacity: 12 gal. (45.4 L).
 - 7. Material and Finish: Stainless steel, ASTM A480/A480M No. 4 finish (satin).
 - 8. Liner: Reusable, vinyl waste-receptacle liner.

9. Lockset: Tumbler type for towel dispenser compartment and waste receptacle.

D. Soap Dispenser :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
2. Description: Designed for manual operation and dispensing soap in liquid or lotion form.
3. Mounting: Vertically oriented, surface mounted .
4. Lockset: Tumbler type.
5. Refill Indicator: Window type.

E. Grab Bar(TA-01, TA-02, TA-03) :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
2. Mounting: Flanges with concealed fasteners.
3. Material: Stainless steel, 0.05 inch (1.3 mm) thick.
 - a. Finish: Smooth, ASTM A480/A480M No. 4 finish (satin) on ends and slip-resistant texture in grip area.
4. OD: 1-1/2 inches (38 mm).
5. Configuration and Length: As indicated on Drawings.

F. Mirror Unit (TA-04) :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASI-American Specialties, Inc.
 - b. Bobrick Washroom Equipment, Inc.
 - c. Bradley Corporation.
2. Frame: Stainless steel channel .
 - a. Corners: Manufacturer's standard .
3. Size: As indicated on Drawings.
4. Hangers: Manufacturer's standard rigid, tamper and theft resistant.

2.3 UNDERLAVATORY GUARDS

A. Underlavatory Guard :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Buckaroos, Inc.
 - b. Plumberex Specialty Products, Inc.
 - c. Truebro; IPS Corporation.
2. Description: Insulating pipe covering for supply and drain piping assemblies that prevents direct contact with and burns from piping; allow service access without removing coverings.
3. Material and Finish: Antimicrobial, molded plastic, white.

2.4 MATERIALS

- A. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.031-inch- (0.8-mm-) minimum nominal thickness unless otherwise indicated.
- B. Steel Sheet: ASTM A1008/A1008M, Designation CS (cold rolled, commercial steel), 0.036-inch- (0.9-mm-) minimum nominal thickness.
- C. Fasteners: Screws, bolts, and other devices of same material as accessory unit, unless otherwise recommended by manufacturer or specified in this Section, and tamper and theft resistant where exposed, and of stainless or galvanized steel where concealed.
- D. Chrome Plating: ASTM B456, Service Condition Number SC 2 (moderate service).
- E. Mirrors: ASTM C1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

2.5 FABRICATION

- A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.
- B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install accessories in accordance with manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.
 - 1. Remove temporary labels and protective coatings.
- B. Grab Bars: Install to comply with specified structural-performance requirements.
- C. Shower Seats: Install to comply with specified structural-performance requirements.

3.2 ADJUSTING AND CLEANING

- A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.
- B. Clean and polish exposed surfaces in accordance with manufacturer's written instructions.

END OF SECTION

SECTION 11 1313 - LOADING DOCK BUMPERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes loading dock bumpers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of loading dock bumper.
- B. Shop Drawings: For dock bumpers. Include plans, elevations, sections, and attachment details.

PART 2 - PRODUCTS

2.1 LOADING DOCK BUMPERS

- A. General: Surface-mounted bumpers; of type, size, and construction indicated; designed to absorb kinetic energy and minimize damage to loading dock structure.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Floor Products Company, Inc.
 - b. Beacon Industries, Inc.
 - c. Chalfant Sewing Fabricators, Inc.
 - d. Durable Corporation.
 - e. Hugger Dock Equipment Company; Columbus Foam Products, Inc.
 - f. Kelley; An Entrematic brand.
 - g. Pioneer Dock Equipment.
 - h. Rite-Hite Corporation.
 - i. Rotary Products Inc.
 - j. Serco; An Entrematic brand.
 - k. Super Seal Mfg. Ltd.
 - l. Vestil Manufacturing Company.
 - 2. Source Limitations: Obtain from single source from single manufacturer.
- B. Laminated-Tread Loading Dock Bumper : Fabricated from multiple, uniformly thick plies cut from fabric-reinforced rubber tires. Laminate plies under pressure on not less than two 3/4-inch- (19-mm-) diameter, steel supporting rods that are welded at one end to 1/4-inch- (6-mm-) thick, structural-steel end angle and secured with a nut and angle at the other end. Fabricate angles with predrilled anchor holes and sized to provide not less than 1 inch (25 mm) of tread plies extending beyond the face of closure angles.
 - 1. Thickness: As indicated on Drawings .
 - 2. Horizontal Style: high by length indicated on Drawings .
- C. Anchorage Devices: Galvanized-steel anchor bolts, nuts, washers, bolts, sleeves, cast-in-place plates, and other anchorage devices as required to fasten bumpers securely in place and to suit installation type indicated. Hot-dip galvanized according to ASTM A153/A153M or ASTM F2329/F2329M.

- D. Materials: ASTM A36/A36M for steel plates, shapes, and bars. Hot-dip galvanize according to ASTM A123/A123M.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Loading Dock Bumpers: Attach loading dock bumpers to face of loading dock in a manner that complies with requirements indicated for spacing, arrangement, and position relative to top of platform and anchorage.
 - 1. Welded Attachment: Plug-weld anchor holes in contact with steel inserts and fillet weld at other locations.
 - 2. Bolted Attachment: Attach dock bumpers to preset anchor bolts embedded in concrete or to cast-in-place inserts or threaded studs welded to embedded-steel plates or angles. If preset anchor bolts, cast-in-place inserts, or threaded studs welded to embedded-steel plates or angles are not provided, attach dock bumpers by drilling and anchoring with expansion anchors and bolts.
 - 3. Screw Attachment: Attach dock bumpers to wood construction with lag bolts as indicated.

3.3 ADJUSTING

- A. After completing installation of exposed, factory-finished dock bumpers, inspect exposed finishes and repair damaged finishes.

END OF SECTION

SECTION 11 3013 - RESIDENTIAL APPLIANCES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Cooking appliances.
 - 2. Refrigeration appliances.
- B. Related Requirements:
 - 1. Section 22 4100 "Residential Plumbing Fixtures" for kitchen sinks, dishwasher air-gap fittings, waste (garbage) disposers, and instant hot-water dispensers.

1.2 ALLOWANCES

- A. Furnish residential appliances as part of residential appliance allowance.
- B. Furnish **<Insert item and drawing designation>** as part of **[residential appliance] <Insert allowance designation>** allowance.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required **[Product Data submittal]** **and** **[Samples submittal]**. Ensure compliance with requirements included in **[Section 01 3300 "Submittal Procedures."]** **[Section 11 0413 "Common Submittal Requirements for Equipment."]**
- B. Product Data Submittals: For each product.
 - 1. Include installation details, material descriptions, dimensions of individual components, and finishes for each appliance.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
- C. Sustainable Design Submittals:
 - 1. ENERGY STAR: Product Data for indicated products, showing compliance with requirements for ENERGY STAR product labeling.
- D. Samples: For each exposed product and for each color and texture specified, in **[manufacturer's standard] <Insert dimensions>** size.
- E. Product Schedule: For appliances. **[Use same designations indicated on Drawings.]**

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintains, within <Insert miles (km)> of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- B. Gas-Fuel Conversion: Provide gas-fueled appliances with manufacturer's [**high-altitude**] [**and**] [**propane**] conversion kit installed by a qualified service agency according to manufacturer's written instructions for Project location and type of fuel.
- C. Provide the following upon request:
 - 1. Qualification Data: For manufacturer.
 - 2. Product Certificates: For each type of appliance.
 - 3. Field quality-control reports.

1.7 WARRANTY

- A. Special Warranties: Manufacturer agrees to repair or replace residential appliances or components that fail in materials or workmanship within specified warranty period[.][**except as qualified below:**]
 - 1. Warranty Period: [**Two**] [**Five**] <Insert number> years from date of Substantial Completion.
- B. Microwave Oven: [**Full warranty, including parts and labor,**] [**Limited warranty, including parts and labor for first year and parts thereafter,**] for on-site service [**on the magnetron tube**] <Insert requirement>.
 - 1. Warranty Period: [**Two**] [**Five**] <Insert number> years from date of Substantial Completion.
- C. Refrigerator/Freezer, Freezer, and Ice maker, Sealed System: [**Full warranty, including parts and labor,**] [**Limited warranty, including parts and labor for first year and parts thereafter,**] for on-site service on the product.
 - 1. Warranty Period for [**Sealed Refrigeration System**] <Insert item>: [**Two**] [**Five**] <Insert number> years from date of Substantial Completion.
 - 2. Warranty Period [**for Other Components**] <Insert requirement>: [**Two**] <Insert number> years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain [**residential appliances from single source**] [**and**] [**each type of residential appliance from single manufacturer**].

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Appliances: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Accessibility: Where residential appliances are indicated to comply with accessibility requirements, comply with applicable provisions in [the DOJ's 2010 ADA Standards for Accessible Design] [the ABA standards of the Federal agency having jurisdiction] [and] [ICC A117.1] <Insert requirement>.

2.3 COOKING APPLIANCES

A. Microwave Oven <Insert drawing designation>:

1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Amana; Whirlpool Corporation.
 - b. Bosch US; BSH Home Appliances Corporation.
 - c. Dacor, Inc.
 - d. DCS Appliances; Fisher and Paykel Appliances Ltd.
 - e. Fisher & Paykel Appliances Ltd.
 - f. Frigidaire.
 - g. Gaggenau; BSH Home Appliances Corporation.
 - h. GE Appliances; Haier Group.
 - i. Jennair; Whirlpool Corporation.
 - j. Kenmore; Transformco SR Brands LLC.
 - k. KitchenAid; Whirlpool Corporation.
 - l. LG Electronics USA, Inc.; LG Electronics Inc.
 - m. Maytag; Whirlpool Corporation.
 - n. Miele.
 - o. Samsung Electronics America, Inc. (SEA); Samsung Electronics Co., Ltd. (SEC).
 - p. Sharp Electronics Corp.
 - q. Thermador; BSH Home Appliances Corporation.
 - r. Viking Range, LLC; Middleby Corporation.
 - s. Whirlpool Corporation.
 - t. Wolf; Sub-Zero Group, Inc.
2. Mounting: Undercabinet Wall cabinet Insert requirement.
3. Type: Conventional Convection Insert type.
4. Dimensions:
 - a. Width: [24 inches (610 mm)] [30 inches (762 mm)] [As indicated on Drawings] <Insert dimension>.
 - b. Depth: [19-1/2 inches (495 mm)] [As indicated on Drawings] <Insert dimension>.
 - c. Height: [14 inches (356 mm)] [18 inches (457 mm)] [As indicated on Drawings] <Insert dimension>.
5. Capacity: 1.5 cu. ft. (0.04 cu. m) 2.0 cu. ft. (0.06 cu. m) Insert capacity.
6. Oven Door: Door with observation window [and pull handle] [and pushbutton latch release] <Insert requirement>.
7. Exhaust Fan: [Variable] [Two] [Four]-speed fan, [vented to outside] [nonvented, recirculating type with charcoal filter] and with [manufacturer's standard] [300 cfm (140 L/s)] <Insert value> capacity.
8. Microwave Power Rating: [Manufacturer's standard] [1000 W] <Insert power rating>.

- a. Convection Element Power Rating: [Manufacturer's standard] [1450 W] <Insert power rating>.
- 9. Electric Power Supply: [120 V, 60 Hz, 1 phase, 15 A] [As indicated on Drawings] <Insert requirement>.
- 10. Controls: Digital panel controls and timer display.
- 11. Other Features: [Turntable] [temperature probe] [and] [lock-out feature] <Insert feature>.
- 12. Material: Porcelain-enameled steel Stainless steel Manufacturer's standard Insert material.
 - a. Color/Finish: [White] [Black] <Insert color or finish>.

2.4 REFRIGERATION APPLIANCES

- A. Refrigerator/Freezer <Insert drawing designation>: One-door refrigerator with freezer compartment inside Two-door, side-by-side refrigerator/freezer Two-door refrigerator/freezer with freezer on top Two-door refrigerator/freezer with freezer on bottom Insert description and complying with AHAM HRF-1.
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Amana; Whirlpool Corporation.
 - b. Bosch US; BSH Home Appliances Corporation.
 - c. Dacor, Inc.
 - d. DCS Appliances; Fisher and Paykel Appliances Ltd.
 - e. Fisher & Paykel Appliances Ltd.
 - f. Frigidaire.
 - g. Gaggenau; BSH Home Appliances Corporation.
 - h. GE Appliances; Haier Group.
 - i. Jennair; Whirlpool Corporation.
 - j. Kenmore; Transformco SR Brands LLC.
 - k. KitchenAid; Whirlpool Corporation.
 - l. LG Electronics USA, Inc.; LG Electronics Inc.
 - m. Maytag; Whirlpool Corporation.
 - n. Miele.
 - o. Samsung Electronics America, Inc. (SEA); Samsung Electronics Co., Ltd. (SEC).
 - p. Thermador; BSH Home Appliances Corporation.
 - q. Viking Range, LLC; Middleby Corporation.
 - r. Whirlpool Corporation.
 - s. Wolf; Sub-Zero Group, Inc.
 - 2. Type: Freestanding Built in Undercounter.
 - 3. Dimensions:
 - a. Width: [16 inches (406 mm)] [24 inches (610 mm)] [27 inches (686 mm)] [30 inches (762 mm)] [36 inches (914 mm)] [42 inches (1067 mm)] [48 inches (1219 mm)] [As indicated on Drawings] <Insert dimension>.
 - b. Depth: [24 inches (610 mm)] [27 inches (686 mm)] [33-1/4 inches (845 mm)] [As indicated on Drawings] <Insert dimension>.
 - c. Height: [34-1/2 inches (876 mm)] [70 inches (1778 mm)] [73 inches (1854 mm)] [84 inches (2134 mm)] [As indicated on Drawings] <Insert dimension>.
 - 4. Storage Capacity:

- a. Refrigeration Compartment Volume: [15.6 cu. ft. (0.44 cu. m)] <Insert volume>.
- b. Freezer Volume: [5.13 cu. ft. (0.15 cu. m)] <Insert volume>.
- c. Shelf Area: [Three] <Insert number> adjustable [wire] [glass] shelves, [26 sq. ft. (2.42 sq. m)] <Insert area>.
- d. <Insert storage requirement>.
- 5. General Features:
 - a. Door Configuration: [Framed] [Overlay].
 - b. Dispenser in door for [ice] [and] [cold water] [with dispenser lock].
 - c. Built-in water-filtration system.
 - d. Dual refrigeration systems.
 - e. Separate [touch-pad] temperature controls for each compartment.
 - f. <Insert feature>.
- 6. Refrigerator Features:
 - a. Interior light in refrigeration compartment.
 - b. Compartment Storage: [Wine racks] [vegetable crisper] [and] [meat compartment] <Insert requirement>.
 - c. Door Storage: [Glazed door without storage] [Modular compartments] [1 gal. (3.8 L) milk-container storage] <Insert requirement>.
 - d. Temperature-controlled meat/deli bin.
 - e. <Insert feature>.
- 7. Freezer Features: [One] [Two] <Insert number> freezer compartment(s) [with door(s)] [configured as pull-out drawer(s)].
 - a. [Automatic] [Manual] defrost.
 - b. Interior light in freezer compartment.
 - c. Automatic icemaker and storage bin.
 - d. <Insert feature>.
- 8. Front Panel(s): [Manufacturer's standard] [Wood panel(s) to match kitchen cabinets] [Porcelain enamel] [Stainless steel] [Wood-panel insert(s) specified in Section 06 4113 "Wood-Veneer-Faced Architectural Cabinets" to match kitchen cabinets] [Wood-panel insert(s) specified in Section 12 3530 "Residential Casework" to match kitchen cabinets] [Reversible panel(s) with choice of colors] <Insert description>.
 - a. Panel Color: [White] [Black] <Insert color(s)>.
- 9. Appliance Color/Finish: [White] [Black] [Stainless steel] <Insert color or finish>.

2.5 GENERAL FINISH REQUIREMENTS

- A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, power connections, and other conditions affecting installation and performance of residential appliances.

- B. Examine roughing-in for piping systems to verify actual locations of piping connections before appliance installation.
- C. Examine walls, ceilings, and roofs for suitable conditions where [**overhead exhaust hoods**] [**downdraft exhaust**] [**and**] [**microwave ovens with vented exhaust fans**] will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install appliances according to manufacturer's written instructions.
- B. Built-in Equipment: Securely anchor units to supporting cabinets or countertops with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.
- C. Freestanding Equipment: Place units in final locations after finishes have been completed in each area. Verify that clearances are adequate to properly operate equipment.
- D. Range Anti-Tip Device: Install at each range according to manufacturer's written instructions.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Perform visual, mechanical, and electrical inspection and testing for each appliance according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
 - 2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After installation, start units to confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.
- B. An appliance will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain residential appliances.

END OF SECTION

SECTION 11 4000 - FOODSERVICE EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fabricated equipment.
 - 2. Self-contained refrigeration equipment.

1.2 COORDINATION

- A. Coordinate foodservice equipment layout and installation with other work, including layout and installation of lighting fixtures, HVAC equipment, and fire-suppression system components.
- B. Coordinate locations and requirements of utility service connections.
- C. Coordinate sizes, locations, and requirements of the following:
 - 1. Overhead equipment supports.
 - 2. Equipment bases.
 - 3. Floor depressions.
 - 4. Insulated floors.
 - 5. Floor areas with positive slopes to drains.
 - 6. Floor sinks and drains serving foodservice equipment.
 - 7. Roof curbs, equipment supports, and penetrations.

1.3 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of construction contiguous with foodservice equipment by field measurements before fabrication. Indicate measurements on Coordination Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. NSF Standards: Provide equipment that bears NSF Certification Mark or UL Classification Mark certifying compliance with applicable NSF standards.
- B. BISSC Standards: Provide bakery equipment that complies with BISSC/Z50.2.
 - 1. Provide BISSC-certified equipment[, **with certification verified by a third-party agency**].
- C. UL Certification: Provide electric and fuel-burning equipment and components that are evaluated by UL for fire, electric shock, and casualty hazards according to applicable safety standards, and that are UL certified for compliance and labeled for intended use.
- D. Steam Equipment: Provide steam-generating and direct-steam heating equipment that is fabricated and labeled to comply with 2013 ASME Boiler and Pressure Vessel Code.

- E. Regulatory Requirements: Install equipment to comply with the following:
 - 1. ASHRAE 15, "Safety Code for Mechanical Refrigeration."
 - 2. NFPA 54, "National Fuel Gas Code."
 - 3. NFPA 70, "National Electrical Code."
 - 4. NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations."
- F. Seismic Restraints: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines," Appendix A, "Seismic Restraint Details," unless otherwise indicated.

2.2 FABRICATED EQUIPMENT

- A. Stainless Steel Tables ST-01):
 - 1. Description: Flat-countertop table.
 - a. Tops: Stainless steel, Type 304, 0.062 inch (1.59 mm) thick, reinforced and sound deadened.
 - 1) Back Splash: Manufacturer's standard height.
 - 2) Edge: Bullnose on four sides.
 - b. Welded Undershelf: Stainless steel, Type 304, 0.050 inch (1.27 mm) thick.
 - c. Crossbracing: Stainless steel tubing, [bolted] [welded] to legs.
 - d. Sink: Stainless steel, Type 304, 0.078 inch (1.98 mm) thick, welded into tabletop and including the following:
 - 1) Faucet and Spout: .
 - 2) Vacuum breaker.
 - 3) Leverwaste.
 - 4) Basket strainer.
 - 5) Tail piece.
 - e. Legs: Stainless steel tubing.
 - f. Feet: Stainless steel adjustable bullets.
 - 2. Materials:
 - a. Stainless Steel Sheet: ASTM A240/A240M, austenitic stainless steel, type as indicated.
 - b. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B, with minimum G90 (Z275) coating.
 - 3. Stainless Steel Finish: Directional satin finish, ASTM A480/A480M, No. 4.

2.3 SELF-CONTAINED REFRIGERATION EQUIPMENT

- A. Refrigeration Equipment <Insert drawing designation>: Refrigerators Freezers.
 - 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Insert manufacturer's name.
 - 2. Description: Reach-in Roll-in Pass-through type.
 - a. Exterior Finish: Stainless steel.
 - b. Interior Finish: [Stainless steel] [Manufacturer's standard].
 - c. Doors: [Full length] [Half-length] [In configuration shown on Drawings].
 - d. Accessories:
 - 1) Casters.

- 2) Stainless steel back with rear louvers.
 - 3) Re-hinging feature for doors.
 - 4) Hinged glass doors and fluorescent fixtures.
 - 5) Tray Slides: For <Insert description> sheet pans.
 - 6) [Chrome-Plated] [Stainless steel] Shelves: <Insert quantity>.
 - 7) Loading Rack: <Insert requirements>.
 - 8) Transfer Carriage: <Insert requirements>.
 - e. Electrical Service: Equip unit with plug and cord for [service indicated on Drawings] <Insert requirements>.
- B. Undercounter Refrigeration Equipment <Insert drawing designation>: Refrigerators Freezers.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Insert manufacturer's name.
 2. Description: Compact unit with rear-mounted, self-contained refrigeration system.
 - a. Accessories:
 - 1) Stainless steel top with backsplash.
 - 2) Stainless steel back panel.
 - 3) Casters: [6 inches (152 mm)] [4 inches (102 mm)] [3-1/2 inches (89 mm)] high.
 - 4) Utility Base: 6 inches (152 mm) high.
 - 5) Shelves: <Insert description and quantity>.
 - 6) Stacking kit.
 - b. Electrical Service: Equip unit with plug and cord for [service indicated on Drawings] <Insert requirements>.
- C. Merchandiser Refrigeration Units <Insert drawing designation>:
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Insert manufacturer's name.
 2. Description: Curved-glass, self-contained refrigerator Sliding-glass, self-contained refrigerator Sliding-glass, self-contained freezer Insert description.
 - a. Exterior Finish: [Manufacturer's standard] [Stainless steel] <Insert requirements>.
 - b. Interior Finish: [Manufacturer's standard] [Stainless steel] [White] <Insert requirements>.
 - c. Accessories:
 - 1) Door locks.
 - 2) Fluorescent Light Fixtures: <Insert quantity>.
 - 3) Base: <Insert requirements>.
 - 4) Casters: <Insert requirements>.
 - 5) Legs: <Insert requirements>.
 - 6) Chrome-Plated Shelves: <Insert quantity>.
 - d. Electrical Service: Equip unit with plug and cord for [service indicated on Drawings] <Insert requirements>.
- D. Ice-Making Machine <Insert drawing designation>:

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Insert manufacturer's name.
2. Description: Undercounter Freestanding units.
 - a. Production: Ice **[cubes] [cubes, dice] [cubes, half-dice] [flakes] [chipelets (compacted flake ice)]**.
 - b. Capacity: **<Insert lb (kg)>** per 24-hour period.
 - c. Accessories:
 - 1) Storage Bin: **<Insert requirements>**.
 - a) Storage Capacity: **<Insert lb (kg)>**.
 - 2) Stainless steel stand and legs.
 - 3) Water filter.
 - d. Electrical Service: Equip unit for connection to **[service indicated on Drawings] <Insert requirements>**.

2.4 MISCELLANEOUS MATERIALS

- A. Installation Accessories, General: NSF certified for end-use application indicated.
- B. Elastomeric Joint Sealant: ASTM C920; silicone. Type S (single component), Grade NS (nonsag), Class 25, Use NT (nontraffic) related to exposure, and Use M, G, A, or O as applicable to joint substrates indicated.
 1. Public Health and Safety Requirements:
 - a. Sealant is certified for compliance with NSF standards for end-use application indicated.
 - b. Washed and cured sealant complies with the FDA's regulations for use in areas that come in contact with food.
 2. Cylindrical Sealant Backing: ASTM C1330, Type C, closed-cell polyethylene, in diameter greater than joint width.

2.5 FINISHES

- A. Stainless Steel Finishes:
 1. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
 2. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 - a. Run grain of directional finishes with long dimension of each piece.
 - b. When polishing is completed, passivate and rinse surfaces. Remove embedded foreign matter and leave surfaces chemically clean.
- B. Powder-Coat Finishes: Immediately after cleaning and pretreating, electrostatically apply manufacturer's standard, baked-polymer, thermosetting powder finish. Comply with resin manufacturer's written instructions for application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install foodservice equipment level and plumb, according to manufacturer's written instructions.
 - 1. Connect equipment to utilities.
 - 2. Provide cutouts in equipment, neatly formed, where required to run service lines through equipment to make final connections.
- B. Complete equipment assembly where field assembly is required.
 - 1. Provide closed butt and contact joints that do not require a filler.
 - 2. Grind field welds on stainless steel equipment until smooth and polish to match adjacent finish.
- C. Install equipment with access and maintenance clearances that comply with manufacturer's written installation instructions and with requirements of authorities having jurisdiction.
- D. Install cabinets and similar equipment on bases in a bed of sealant.
- E. Install closure-trim strips and similar items requiring fasteners in a bed of sealant.
- F. Install joint sealant in joints between equipment and abutting surfaces with continuous joint backing unless otherwise indicated. Produce airtight, watertight, vermin-proof, sanitary joints.

3.2 CLEANING AND PROTECTING

- A. After completing installation of equipment, repair damaged finishes.
- B. Clean and adjust equipment as required to produce ready-for-use condition.
- C. Protect equipment from damage during remainder of the construction period.

3.3 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain foodservice equipment.

END OF SECTION

SECTION 11 9519 - ANIMAL EQUIPMENT**PART 1 GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Provide and install specialized animal equipment including drinkers, sea lion scale and sea lion hoist, as shown on the drawings, specified herein, or needed for a complete and proper installation.
2. Work of this Section Includes:
 - a) Animal Drinkers
3. Coordinate with the closely related work of the following sections:
 - a) Artificial Rockwork – Section 03 37 13
 - b) Keeper Access Doors, Frames, and Caging – Section 08 34 53

B. Related Sections:

Section 03 30 00 Cast-in-Place Concrete

Section 07 92 00 Joint Sealants

Division 22 Plumbing

Division 26 Electrical

1.2 SUBMITTALS**A. General:**

1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
2. Within 35 calendar days after the Contractor has received the Owner's Notice to Proceed, submit all items listed below.

B. Product Data:

1. Materials list of items proposed to be provide under this Section.
2. Manufacturers' specifications and other data needed to prove compliance with the specified requirements.
3. Submit sufficient technical data to enable the interface of the work of this section with the work of mechanical and electrical trades
4. Shop Drawings and details completely showing the installation, and anchorage of the proposed construction, and the interface of the work of this section with the work of adjacent trades.
5. Manufacturer's recommended installation procedures which, when approved by the Consultant, will become the basis for accepting or rejecting actual installation procedures used on the Work.

C. Samples:

Accompanying the Shop Drawings submit:

1. Samples of finishes, showing complete range of color proposed for use on each item of this Work.

1.3 QUALITY ASSURANCE**A. Workers:**

Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.4 PRODUCT HANDLING

A. General:

Comply with the pertinent provisions of Sections of 01 60 00 Product Requirements.

B. Protection:

Use all means necessary to protect materials of this Section before, during, and after installation and to protect installed Work and materials of all other trades.

C. Replacements:

In the event of damage, immediately make all repairs and replacements necessary to the approval of the Consultant and at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 DRINKERS

A. Nelson Drinkers; www.nelsonmfg.com

1. Nelson Freestanding 730-10 series Animal Drinker.
 - a) Coordinate with location of concrete mounting pad and plumbing/water supply. Height: 11 inches; finish: stainless steel.
 - b) Provide all optional accessories for waterline, and anchorage.
 - c) Provide freeze protection
 - d) Water consumption
2. Nelson Wall mounted 730-10W series Animal Drinker.
 - a) Coordinate with location of concrete mounting pad and plumbing/water supply. Height: 11 inches; finish: stainless steel.
 - b) Provide all optional accessories for waterline, and anchorage.
 - c) Provide freeze protection
 - d) Water consumption

PART 3 EXECUTION

3.1 SURFACE CONDITIONS

- #### A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Shop Drawings:

Install the work of this Section in strict accordance with the Shop Drawings as approved by the Consultant.

B. Coordination:

Coordinate as required with other trades to assure proper and adequate provision in the work of those trades for interface with the work of this Section.

C. Manufacturer's Procedures:

Install the work of this section in strict accordance with the manufacturer's recommended installation procedures.

D. Codes:

Install the work of this Section in strict accordance with the pertinent codes and requirements of governmental agencies.

E. Anchoring:

Provide secure anchoring of all materials, firmly in position, and capable of long life under hard use.

3.3 OPERATION, ADJUSTMENT, AND CLEAN UP

A. Operating Cycles:

Upon completion of the installation and hookup to utilities, put all operating components through at least five complete operating cycles, adjusting as necessary to achieve optimum levels of operation.

B. Touch-Up:

Visually inspect all exposed surfaces and touch-up scratches and abrasions, which must be invisible to the unaided eye from a distance of five feet.

C. Clean-Up:

Promptly remove from the job site all cartons and packing material associated with the work of this Section.

END OF SECTION

FOR REFERENCE ONLY

SECTION 12 1423 - SIMULATED NATURE - ARTIFICIAL PLANTS**PART 1 GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Fabricate and install simulated-nature trees and fallen logs as shown on the drawings and described herein.
2. Work of this section will be fabricated by the owner and installed by the contractor.
3. Work of this section includes:
4. Simulated nature trees and fallen logs
5. Simulated nature roots
6. See Part Four for a schedule of Artificial Plants.
7. Provide support structures and armatures, foundations, and connections for all work of this section.

B. Related Work:

Section 03 30 00 Cast-in-Place Concrete

Section 03 37 00 Artificial Rockwork

Section 13 31 20 Cable Supported Mesh Structures

Section 32 94 26 Natural Deadfall

1.2 ADMINISTRATIVE REQUIREMENTS**A. Coordination:**

Coordinate components of the work of this Section with work performed by other Sections in sufficient time to allow for other components of the work to incorporate requirements of this Section without causing delay to the work, including the following:

1. Foundations of Adjacent Structures: coordinate with the foundation requirements of all adjacent buildings and structures.
2. Cable Supported Mesh Structures
3. Shotcrete Rockwork

B. Pre-Construction Meeting:

Arrange a site meeting attended by the Contractor's superintendent, the Subcontractor's representative and foreman for this project, the Consultant, materials supplier(s), and other relevant personal in accordance with Section 01 31 19 – Project Meetings before commencement of work for this Section; agenda for meeting will include the following:

1. Confirmation of specifications and details for the project
2. Review of required fastening and joining methods
3. Review of samples
4. Review of finishing methods and proposed coatings
5. Additional items that are required for identification of installation and fabrication concerns

1.3 SYSTEM DESCRIPTION**A. Delegated Design:**

1. The work of this section requires professional design services or certifications by design professionals employed by the fabricator, and who are not the Consultant.

B. Artistic Interpretation:

1. Provide artists and craftsmen skilled in the creation of the simulated-nature plants, who will interpret and complete the design of the concepts specified in this section.
 2. Complete the design, fabricate, place, and install the work of this section in such a manner as to replicate the forms, structures, finishes, and colors described by the written descriptions and reference photographs contained herein and/or on the drawings.
- C. Owner's and Consultant's Direction:
1. It is intended that the finished products of work in this Section produce the aesthetic effects shown on the drawings and indicated in the project manual and graphics manual.
 2. The Consultant explicitly reserves the right to monitor the work for aesthetic quality until the specified effects are achieved.
 3. The Consultant will decide questions of aesthetic effect.
- D. Materials and Structures - Alternative Means and Methods:
1. Exhibit Design Drawings:
 - a) The design, layout, and details referenced by this Section have been developed for the purposes of establishing a standard of quality for the work.
 - b) At its option the Contractor may propose alternative means and methods of construction: including alternative materials, waterproofing systems, and structural systems.
 2. Alternative Means and Methods:

Alternative means and methods will be considered only when fully described at the time of tendering, in the form provided on tender documents and when substantiated by the Contractor's submittal of the following information:

 - a) Manufacturer's specifications for proposed materials.
 - b) Minimum of three (3) projects where the proposed materials or structural systems have been used successfully.
 3. Final selection of specific materials for each exhibit element must be approved by the Consultant.
 4. Provide appropriate documentation that all proposed materials meet the specific performance requirements specified below.
- E. Performance Standards:
1. General:
 - a) All exposed surfaces and finishes shall use non-toxic materials.
 - b) All materials shall be cleanable and UV resistant.
 - c) Grout voids solid or provide 800mm diameter access panels in locations concealed from any views of guests.
 2. Service Life:
 - a) All materials and/or completed fabrications must have a ten (10) year service life for finishes and a twenty (20) year structural service life.
 - b) Finishes must be capable of resisting any visible damage for a 5-year active service life.
 - c) All integral and applied color must resist fading for a minimum of 5 years of active service life in the project environment(s).
- F. Structural Design:
1. General:
 - a) Provide the structural engineering design for the simulated deadfall and its foundations.
 - b) Drawings and Calculations:

Provide complete design, calculations, and drawings.

- c) Licensed Engineer:
Design drawings will be prepared, approved, signed and sealed by a Professional Engineer licensed in the jurisdiction in which the project will be constructed.
- d) Maintain the general design concept as shown, without decreasing or increasing sizes of members and without altering profiles and alignment, except as approved by the Consultant.
- 2. Design of Simulated-Nature Plants:
Design all of the elements comprising the simulated-nature plants shown on the drawings, including but not limited to the following:
 - a) Skin Panels:
Design the concrete, epoxy, and/or resin mixes, fiber and steel reinforcing, required thicknesses, attachments, and support armatures.
 - b) Support Structure:
Design the support structure and its foundations to support the skin panels.
- 3. Design Loads:
Design all elements and connections for the following loads:
 - a) Dead loads including plants and soil
 - b) Live loads due to visitors and maintenance activities including the required vehicles and staff,
 - c) Seismic, wind, and snow loads where applicable.
 - d) In addition to the above loads, design all elements for the following loads:
Concentrated gravity live load of 5 kN at any one location.
- 4. Structural Design Coordination:
 - a) Design the openings and rebates required for the work of Section 08 84 00.
 - b) Design the inlet and outlet structures and the penetrations for pipe systems as required for the work of Division 17.
- 5. Geotechnical Investigations and Recommendations:
 - a) The following geotechnical investigations and recommendations provide the basis for the structural and foundation design of the work of this section:
 - b) Geotechnical Investigation See Section 02 31 00 Soil Investigations.
- 6. Foundation Design:
 - a) Design foundations, when required, in accordance with all pertinent recommendations of the geotechnical Investigations, clarifications, and additions.
 - b) Design the foundations to limit movement due to frost heave or soil movement.
 - c) Thicken paving slabs when required to carry the loads imposed.
- 7. Safety Factors:
 - a) Use liberal safety factors that exceed Code minimums as noted herein.
 - b) Working stresses shall not exceed the lower value of one-third of the yield strength or one-fifth of the ultimate strength of the material.
 - c) Design fiberglass reinforced concrete (FRC), glass fiber reinforced resin (FRP), and metal fabrications for the stresses to which these products will be subjected during fabrication, erection, and continuous operation.
- G. Play Safety Standards:
 - 1. Comply with the referenced standards for children's play included in this section.
 - 2. Comply with or exceed all standards for entrapment, entanglement, and projection hazards; slip resistance of finishes; and all other aspects of play safety covered by the standards.
- H. Electrical Bonding:

1. Bonding:
2. Provide bonding for the equipotential plane and for metal structures, surfaces, and fixed metal equipment per all requirements of the US National Electrical Code Article 547 and 680.

I. Building Permits:

The Contractor will obtain all required permits and approvals for proposed and alternative structural systems.

1.4 SUBMITTALS

A. General:

1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
2. Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit all items listed below.

B. Design Drawings:

1. Delegated Design:
 - a) Submit complete drawings accurately indicating all proposed simulated-nature plants described in this Section, prepared in accordance with the following provisions:
 - 1) Verify materials selection and sizes.
 - 2) Verify fabrication and connection details for the simulated nature plants or suggest alternative connection details.
 - 3) Complete the design utilizing the components specified in Part 2 of this Section.
 - 4) Revise drawings as required by the permitting authorities and resubmit.
2. Delegated Design Submittals:
 - a) Provide all submittals described in Section 01 33 50 – Delegated Design Submittals as required for the work of this Section.
3. Design Notes and Calculations:

Submit design notes and calculations; signed and sealed by Professional Engineer when requested by Consultant.

C. Product and Materials Data:

1. Representative samples of materials for testing, mix proportion testing, and preparation of pre-construction samples and mock-ups.
2. Appropriate documentation that all proposed materials meet the performance requirements specified herein.
3. Manufacturers cut sheets and literature fully describing all manufactured products and materials.

D. Sketches, Mock-ups and Samples:

1. Sketches:
 - a) Provide sketches developing the concepts for each simulated nature plant of this section.
 - b) Submit color sketches sufficient to portray the completed work and to indicate all significant details.
2. Surface Material Samples:

Provide full scale samples of each finish material showing the texture and color of the finished surface. See Section 4 for sample descriptions.
3. Maquettes:

Provide a maquette of each simulated nature plant at $\frac{1}{2}" = 1'-0"$. Maquette shall clearly show the surface textures, shape and size of the finished simulated nature plant and be

capable of being incorporated into the Shotcrete model described in Section 03 37 13 Shotcrete.

4. Full Size Patterns:
Provide full size patterns for all simulated-nature plants for approval by Consultant and Owner prior to taking molds for casting or commencing fabrication (as necessary).
- E. Shop Drawings:
 1. Provide complete shop drawings for all work of this section indicating the shape, size, and location of all elements.
 2. Provide details of construction techniques, requirements for anchorage to the substrates provided by other contractors, details of connections between differing materials, structural details of internal armature, and required connections.
 3. Provide all mounting details.
 4. Provide complete specifications for all proposed materials. These specifications will provide the basis for the Owner's quality assurance testing.
 5. No materials shall be fabricated or delivered to the site until the shop drawings have been reviewed, approved, and returned.
- F. Maintenance Data:
 1. Provide recommended cleaning techniques and products for all sculpture.

1.5 QUALITY ASSURANCE

A. Codes and Standards:

Comply with pertinent provisions of following codes and standards:

1. Codes
 - a) Conform to all applicable requirements of the local building codes, latest editions.
 - b) International Building Code, Chapter 19 latest edition and local amendments.
2. Testing Agencies
 - a) American Society for Testing and Materials (ASTM), latest edition.
3. Fire Safety
 - a) Surface Burning:
 - b) UL 723 (ASTM E84) (CAN - ULC S102.2) Test for Surface Burning:
 - c) Use only materials that have been tested and accepted for labeling and meeting requirements of the Authority Having Jurisdiction
 - d) Comply with all current applicable requirements of state and local Fire Marshall.
 - e) ANSI / NFPA 101 Life Safety Code, current edition
 - f) ANSI / NFPA 150 Animal Standard on Fire & Life Safety in Animal Housing Facilities, current edition
4. Concrete Standards
 - a) ACI 318 Building Code Requirements for Reinforced Concrete.
 - b) CRSI "Manual of Standard Practice";
 - c) ACI 315, latest edition, "Manual of Standard Practice for Detailing Reinforcing Bars".
 - d) ACI (American Concrete Institute) 506R-90(95), Guide to Shotcrete.
5. Steel Standards
 - a) 'Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings' by AISC, latest edition.
 - b) AISC "Code of Standard Practice";
 - c) AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
6. Accessibility Standards

- a) ISO Guide 71, Standards for Accessible Design.
- b) USA, 2010 ADA Standards for Accessible Design
7. Play Standards
 - a) Public Playground Safety Handbook, US Consumer Products Safety Standards, latest edition.
 - b) Standard Consumer Safety Performance Specification for Playground Equipment for Public Use, ASTM F1487.
- B. Welding:
 1. Perform welding with electric arc process and in accordance with AWS "Code for Arc and Gas Welding in Building Construction."
 2. Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedures".
 3. Welder shall be certified in conformance with (AWS) (WABO) requirements.
- C. Qualifications:
 1. Established firm or individual with a minimum of five (5) years experience in successfully constructing elements of similar nature to the work of this section.
 2. Provide resumes for key personnel performing the work.
 3. Submit references and photographic documentation of previous projects documenting the experience and ability to construct the work of this section.
 4. Acceptable Fabricators:

The following list of fabricators and installers is derived from previous projects indicating a successful record of fabrication and installation of similar complexity and extent as required for this project and are subject to verification of their capabilities before starting work of this section by submittal of documentation indicating that they meet the specified qualifications:

 - a) Cost of Wisconsin, Seattle Washington
Contact: Jeff Sheiber
Telephone: 407-816-2110 ext. 2101
Email: jsheiber@costofwisconsin.com
www.costofwisconsin.com.
 - b) Edge Concrete, Woodinville, Washington
Contact: Wendy Endres
Telephone: 425 482-3343, Fax: 425 482-3342,
Email: wendy@edgeconcretelc.com
www.edgeconcretelc.com.
 - c) The Nassal Company, Orlando Florida 32806
www.nassal.com
 5. Substitute Fabricators:

The Contractor may choose to select any of the listed fabricators or installers in accordance with Section 01 60 00 – Product Requirements or elect to solicit additional fabricators installers having similar qualifications, experience and proven capabilities as the acceptable installers listed above and provided that the Contractor makes requests for substitution in accordance with Section 01 25 00 – Substitutions a minimum of ten (10) days in advance of Bid Closing as follows:

 - a) Bidders wishing to use a fabricator or installer that is not identified in this Section must have the proposed fabricator comply with qualification requirements listed in Item .1 above and submit a letter of qualification, including references a minimum of five (5) 8½-inch by 11-inch color photographs of previous comparable work for review and acceptance by the Consultant.

- b) Fabricators wishing to be accepted for the work of this section may independently make application directly to the Consultant as detailed above.
 - c) Acceptance of substitute fabricators will be indicated by a subsequent addendum.
 - d) The Consultant may require additional information and may request a visit to a completed work in order to make a final determination of the fabricator's qualifications.
- D. Shop Fabrication:
- 1. Perform all appropriate work of this section in a shop experienced in the relevant work, in accordance with the standards of quality for the specified trade established in the relevant section as listed under Related Work Described Elsewhere.
 - 2. Preassemble items in the shop to the greatest extent possible to minimize field splicing and assembly.
 - 3. Perform shop or field welding required in connection with the work of this section, adhering strictly to the current pertinent recommendations of CSA W59 or the equivalent American Welding Society standard.
 - 4. Perform welding with electric arc process and in accordance with AWS "Code for Arc and Gas Welding in Building Construction".
 - 5. Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedures".
 - 6. Fabricator shall be certified in accordance with CSA W47.1, Division 1 or 2.1 or according to the equivalent American Welding Society standards.
 - 7. Welder shall be qualified by the Canadian Welding Bureau or certified in conformance with equivalent AWS requirements.
- E. Surface Inspection Prior to Finishes:
- 1. Notify Consultant a minimum of 24-hours prior to application of any finishes to the work of this section.

1.6 PROJECT CONDITIONS

A. Field Measurements:

Secure all field measurements required for proper and adequate fabrication and installation of the work.

B. Templates:

Furnish templates for exact location of all items to be embedded in concrete and setting instructions required for all installation work.

1.7 WARRANTY

- A. Warranty all materials and finishes to give complete and satisfactory service for a period of five (5) year from the date of Final Acceptance of the work. Provide manufacturer's standard warranties on all materials and finishes.

PART 2 PRODUCTS

2.1 FIBER REINFORCED CONCRETE (FRC)

A. General:

- 1. Conform to all applicable requirements of the standard specifications and standards of Part One of this section.
- 2. Provide reinforcement, accessories, and connection materials required in accordance with the Drawings as approved by the Consultant.
- 3. Provide embedded anchors, fasteners, or other items as required by the work of this project.

B. FRC Material**1. Material:**

A composite of washed silica sand, Type III Portland cement modified with a polymer, reinforced with alkaline resistant glass fibers.

Density:..... 54.5kg (120lbs) to 59kg (130lbs) per cubic foot.

Compressive strength:..... 48 MPa (7,000) to 84 MPa (12,000 psi).

Flexural strength (ultimate):..... 14 MPa (2,000) to 28 MPa (4,000 psi).

Impact strength:..... 30 to 60 in. per lb.

Shell thickness:..... 8mm to 16mm

2. Design Mixes:

a) Prepare design mixes for each type of concrete required, and secure the Consultant's approval of the proposed design mix.

b) Prepare mixes by qualified precast concrete manufacturing personnel and approved by the Consultant.

c) Proportion mixes either by laboratory trial batch or field experience methods, using materials to be employed on the Work for each type of concrete required, and complying with ACI 211.1

3. Reinforcing, Armatures, and Supports:

Provide corrosion resistant reinforcing, armatures, and supports to meet structural requirements for support.

2.2 GLASS FIBER REINFORCED RESIN (FRP), POLYESTER, EPOXY, & URETHANE RESINS**A. Design Requirements:**

1. Design shall comply with these specifications and all pertinent Building and Safety Codes.

2. Liberal safety factors shall be used in the design of all products.

3. Working stresses shall not exceed the lower value of one-third of the yield strength or one-fifth of the ultimate strength of the material.

4. Sculptures shall be designed for stresses to which these products will be subjected during fabrication, erection, and continuous operation as shown on the Drawings.

B. Resins:

Glass Fiber Reinforced Resins shall conform to NBS Voluntary Product Standard PS 15-69.

C. Gelcoat:

Gelcoat shall maintain chip resistance and color fastness for minimum five years.

D. Flame Spread:

Glass fiber reinforced resin assemblies shall have a flame spread rating of 25 or less when tested in accordance ASTM E84-81 and will be a Class I material in the Uniform Building Code.

E. Reinforcing, Armatures, and Supports:

Provide corrosion resistant reinforcing, armatures, and supports to meet structural requirements for support.

2.3 FASTENERS**A. General:**

1. Provide zinc-coated or Type A316 stainless steel fasteners.

2. Select fasteners for the type, grade, and class required.

B. Standards:

All fasteners listed below shall comply with ASTM A307 and as follows:

1. Stainless steel bolts, screws, studs: ASTM F738M, Type 316.
2. Stainless steel nuts: ASTM F836M-91, Type 316.
3. Masonry anchorage devices: Expansion shields complying with Fed Spec FF-S-325.
4. Concrete inserts:
 - a) Threaded or wedge type, galvanized ferrous castings, either malleable iron ASTM A47 or cast steel ASTM A27.
 - b) Provide bolts, washers, and shims as required, hot-dip galvanized, ASTM A153.
5. Lock washers: Helical spring type carbon steel, complying with Fed Spec FF-W-84.

2.4 FABRICATION**A. Embedded Metal Artwork:**

1. Confirm artwork content, type, and size prior to fabrication.
2. Confirm colors and finishes prior to fabrication.

B. Artistic Style and Design Intent:

1. The 'realistic' sculpture and artwork will be realistic representations displaying key details of each species.
2. The 'abstract' sculpture and artwork will be abstractions of the actual elements, simplified and softened as required for visitor contact and play.
3. Final styles will be determined through discussions among the Owner, Consultant and Fabricator, and approved based on submission of the specified drawings, maquettes, and patterns.

C. Safety:

1. All portions of the simulated-nature plants within reach of visitors will be touchable, and shall be formed and fabricated to avoid protruding or sharp edges and points that could cause injury as required in the play safety standards referenced in this section.

2.5 FINISHES**A. General:**

1. Provide finishes for all exposed surfaces.
2. All artwork shall be free of scratches, defects, blemishes and warping.
3. All exposed surfaces will be free of burrs, slivers, sharp edges and ridges and smooth and safe to the touch before and after installation.

B. Reference Photographs:

1. The reference photographs included in the specifications and drawings, provide direction by the consultant to the fabricator for the intended colors and textures of the finishes.
2. The fabricator will utilize the reference photographs, drawings, and written specifications as a starting point from which to develop unique sculptures and artwork that carry out the artistic intent described herein.

C. Colors:

1. Use color palettes corresponding to those of the natural specimen or life form or as specified in these documents.
2. Wherever possible the color will be an integral part of the cast, molded, or sculpted material.
3. Highlight and contrasting colors will be applied prior to installation with a medium that is non-toxic, and durable in the operating environment of the installed sculpture.

D. Durability:

1. In areas receiving intense physical contact by visitors, use materials that resist abrasion or damage.
2. Provide clear coats or other means to protect the finished surfaces.
3. Ensure that all textures and colors will be unaffected when cleaned with pressure washers.

2.6 ELECTRICAL GROUNDING

A. General:

1. Ground all embedded metal artwork when required, and in accordance with the relevant electrical and safety codes.

PART 3 EXECUTION

3.1 GENERAL

- #### A. Provide a structural substrate, capable of maintaining the intended shape, containing water in pools, and supporting live and dead loads as specified herein or as required by codes.

B. Finish Coat:

1. Produce the intended color and texture.
2. Provide mix design appropriate for integral color, carving, and texturing, and other aesthetic treatment to create the specified finishes.
3. Provide sufficient thickness to assure structural integrity and bonding to the structural substrate.
4. Provide sufficient thickness to create the specified recreations of natural forms and finishes.

3.2 COORDINATION

A. General:

Verify locations and dimensions with requirements of the drawings and specifications before production and installation begins.

B. Simulated-Nature Plants:

1. Provide all required foundation connection points in coordination with the requirements of Section 03 37 13 Artificial Rockwork.
2. Provide all required foundation connection points in coordination with the requirements of Section 32 13 13 Concrete Paving.

3.3 PANEL FABRICATION

A. General:

1. At the option of the contractor, provide prefabricated Fiber Reinforced Concrete or fiber reinforced plastic panels in areas where this system of construction is structurally and aesthetically appropriate.

B. Molds or Sculpting:

1. Make molds from rigid materials that will result in shapes, textures and dimensions as required for the work described in this section and on the drawings.
2. Sculpt panels to replicate natural plant surfaces as agreed in Part One.

C. Joining Panels:

1. Where panels are specified or have been approved, place into proper position by shimming and bracing as necessary, then fill seams between panels solid with texture coat.
2. Upon installation, field treat and cover joints and seams to match the texture and finish of the material exactly so that joints are not visible or discernable.

3.4 INSTALLATION

A. General:

1. Final placement and installation of simulated-nature plants will be approved on site with Consultant.
2. Install work in strict accordance with the approved Submittals.
3. Employ a qualified, experienced installation team for all work.

B. Placing:

1. Pre-Conditions:
Do not install work on site until the following conditions are met:
2. Final layout plans have been reviewed and approved by Consultant and Owner.
3. Consultant and Owner have reviewed layouts on site, in their final location, through the placement, or of templates.
4. The work of all associated trades has been coordinated.

C. Touchup:

Repair and touch-up all simulated-nature plants after installation to eliminate any visual defects.

D. Protection:

Upon completion of work, clean the simulated-nature plants and protect until final acceptance by the Consultant.

3.5 INSTALLATION

PART FOUR - SCHEDULE OF SIMULATED NATURE PLANTS

4.1 SIMULATED NATURE PLANTS

A. Stand Dead Trees and Fallen Logs

1. Represents the trunk and branching structure of a dead Chisos Oak (*Quercus graciliformis*) or Trumpet Tree (*Tabeaia* sp).
2. Realistic sculpture, colors and textures matching the specified plant species and reference photos.
3. Relief – As required to achieve described texture
4. Quantity – As shown in drawings
5. Size – as shown in the drawings
6. Sample Description:
 - a) Deadfall: Provide (2) 3' long trunk sample measuring 8" in diameter, (1) for each tree species. Include in the sample a branching junction with a branch 5" in diameter. Terminate both the trunk and branch with an irregular broken end. Include areas of bark and areas of exposed sapwood and miscellaneous smaller branching.
 - b) Fine Branching: Provide 3' x 3' x 3' mass of branching of different sizes depicting the branching of the crown of a fallen tree. Half of the sample should depict submerged branching that is darker in color with varying algae growth.

B. Artificial Roots

1. Represents the exposed woody root masses in an eroded earthbank.
2. Realistic sculpture, colors and textures matching the specified plant species and reference photos.
3. Relief – As required to achieve described texture
4. Quantity – As shown in drawings
5. Size – Root diameter varies in size from large main roots to small diameter fine roots as shown in the drawings
6. Placement of all roots shall be done with the oversight/approval of the Owner.

7. Sample Description:
 - a) Exposed Roots: Provide a 3' wide by 3' tall sample of root massing. Incorporate root mass sample into Artificial mudbank sample described in 03 37 13 Shotcrete.
- C. Artificial Vines
 1. Represents the tangled woody vines growing out of the earth and twining around nearby trees.
 2. Realistic sculpture, colors and textures matching the specified plant species and reference photos.
 3. Relief – As required to achieve described texture
 4. Quantity – As shown in drawings
 5. Size – Vine diameter varies in size from large main vines to small diameter fine vines as shown in the drawings
 6. Placement of all vines shall be done with the oversight/approval of the Owner.
 7. Sample Description:
 8. Exposed Roots: Provide a 6'-0" long sample of (3) different vine diameters. Show the termination system/attachment system to be used at the end of each vine sample.

END OF SECTION

FOR REFERENCE ONLY

SECTION 12 3553.13 – METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes metal laboratory casework.
- B. Related Requirements:
 - 1. Refer to Section 12 3553 "General Requirements for Laboratory Casework and Fume Hoods" for all References, Approved manufacturers, Materials, Hardware, Finishes, Installation, etc.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND PRODUCTS

- A. Refer to Section 12 3553 for approved manufacturers.

2.2 CASEWORK DESIGN (STC-01)

- A. Comply with SEFA 8-M "Laboratory Grade Metal Casework."
- B. Full overlay style: Square edged door and drawer fronts overlapping the openings on all four sides. In elevation, hold the reveal between end panel and door or drawer edge to a maximum of 1/8 inch (3 mm) wide. Hold spaces between abutting doors and drawers to a maximum of 1/8 inch (3 mm) wide, both horizontally and vertically, and shall be accurate and uniform, forming a continuous reveal throughout full length of assembled casework. Hold the reveal between top of cabinet and door or drawer edge to a maximum of 1/4 inch (6 mm) wide.
- C. Self-Supporting Units: Completely welded shell assembly without applied panels at ends, backs or bottoms, so that cases can be used interchangeably or as a single, stand-alone unit.
- D. Interior of Case Units: Easily cleanable, flush interior. Base cabinets, 30 inches (750 mm) and wider, with double swinging doors shall provide full access to complete interior without center vertical post.
- E. Secure intersection of case members with spot and arc welds.
- F. Testing of Casework, Tables, and Shelving: Meet or exceed SEFA 8-M.

2.3 CASEWORK FABRICATION

- A. General: Include completely enclosed vertical posts. Include the items of cabinet construction listed. Exclude provisions for doors in open shelf cabinets or cubbies.
- B. Movable Base Cabinets: Provide movable base cabinets as described under Floor Mounted Base Cabinets above, unless modified under this Paragraph:
 - 1. At toespace rail provide leveling glides in lieu of leveling screws.
 - 2. Backs: Provide solid fixed backs on all base cabinets.

C. Wall and Upper Cabinets:

1. End Panels and Backs:

- a. End panels and back formed from a single steel sheet with front edges formed to a channel shape and further offset to form a strike for doors and drawers.
- b. Reinforce at front and rear corners with vertical posts containing shelf adjustment holes, maximum 1/2 inch (12 mm) on centers.

2. Bottoms:

- a. Bottom and bottom rail formed from a single piece of metal with both sides and back formed up with a radius between flange and bottom for ease of cleaning.
- b. Form front rail to provide a strike for doors and drawers.
- c. Reinforce at front corners with gussets.

3. Tops

- a. One piece construction with front edge formed into a channel shape and offset for door recess and to provide a strike for doors. Turn down flanges at back and side edges for welding top to back and end panels.
- b. Reinforce at front corners with gussets.

4. Adjustable Shelves:

- a. Full width with one adjustable shelf for cabinets up to 30 inches (760 mm) high.
- b. Full width with two adjustable shelves for cabinets between 31 (787 mm) high up to 37 inches (940 mm).
- c. Form front and back edges down 3/4 inch (19 mm) and returned back 3/4 inch (19 mm).
- d. For shelves over 36 inches (915 mm) long or 16 inches (400 mm) deep, reinforce with a welded hat channel for the full length of the shelf.
- e. Adjustable on 1/2 inch (12 mm) centers.
- f. Front edge of shelf to be within 1 inch (25 mm) of inside face of door.

5. Hinged Solid Doors:

- a. 3/4 inch (19 mm) double wall assembly.
- b. Reinforce interior of front panel with welded steel hat channels. Prepaint and sound deaden interior. Weld outer corners and grind smooth.
- c. Secure hinges with screws to internal full-height reinforcing in case and door. Hinges shall be removable; welding of hinges is not acceptable.
- d. Doors shall close against rubber bumpers.

6. Hinged Solid Doors: 3/4 inch (19 mm) hardwood plywood with particleboard, MDF or combination core with 1/8 inch (3 mm), Type 1 hardwood edgebanding.

D. Filler Panels:

1. Provide filler panels or scribe strips at exposed to view areas between back of cabinets and walls, between backs of cabinets at end of island or peninsula benches, and at any other area necessary to enclose gaps. For floor mounted cabinets provide all filler panels with bottom 6 inches (152 mm) fixed and the top portion removable. When cabinets abut side walls, provide a minimum 1 inch filler between side of cabinet and wall. For floor mounted cabinets the filler panel includes a toe kick to match adjacent casework.
2. Grind edges and radius corners to eliminate sharp edges.
3. Secure to frame and/or cabinet back and wall with metal angle and oval head screws with finishing washers.
4. Finish color to match color of adjacent casework.

2.4 HARDWARE

- A. Refer to Section 12 3553.

2.5 METAL FINISH

- A. Refer to Section 12 3553.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to Section 12 3553.

END OF SECTION

FOR REFERENCE ONLY

SECTION 12 3661.16 - SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Solid surface material countertops.
 - 2. Solid surface material backsplashes.
 - 3. Solid surface material end splashes.

1.2 ACTION SUBMITTALS

- A. Product Data: For countertop materials.
- B. Sustainable Design Submittals:
 - 1. Chain-of-Custody Certificates: For certified wood products. Include statement of costs.
 - 2. Product Data: For adhesives, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Test Reports: For composite wood products, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.
 - 1. Show locations and details of joints.
 - 2. Show direction of directional pattern, if any.
- D. Samples for Initial Selection: For each type of material exposed to view.
- E. Samples for Verification: For the following products:
 - 1. Countertop material, 6 inches (150 mm) square.
 - 2. One full-size solid surface material countertop, with front edge and backsplash, 8 by 10 inches (200 by 250 mm), of construction and in configuration specified.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For fabricator.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For solid surface material countertops to include in maintenance manuals. Include Product Data for care products used or recommended by Installer and names, addresses, and telephone numbers of local sources for products.

1.5 QUALITY ASSURANCE

- A. Fabricator Qualifications: Shop that employs skilled workers who custom-fabricate countertops similar to that required for this Project, and whose products have a record of successful in-service performance.

- B. Installer Qualifications: Fabricator of countertops.

1.6 FIELD CONDITIONS

- A. Field Measurements: Verify dimensions of countertops by field measurements after base cabinets are installed but before countertop fabrication is complete.

1.7 COORDINATION

- A. Coordinate locations of utilities that will penetrate countertops or backsplashes.

PART 2 - PRODUCTS

2.1 SOLID SURFACE COUNTERTOP MATERIALS (SS-01)

- A. Solid Surface Material: Homogeneous-filled plastic resin complying with ISFA 2-01.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. E. I. du Pont de Nemours and Company.
 - b. LG Chemical, Ltd.
 - c. Swan Corporation (The).
 - d. Wilsonart LLC.
 - 2. Basis-of-Design Products: As scheduled; refer to Finish Schedule.
 - 3. Type: Provide Standard type unless Special Purpose type is indicated.
 - 4. Colors and Patterns: As indicated by manufacturer's designations .
- B. Composite Wood Products: Products shall be made using ultra-low-emitting formaldehyde resins as defined in the California Air Resources Board's "Airborne Toxic Control Measure to Reduce Formaldehyde Emissions from Composite Wood Products" or shall be made with no added formaldehyde.
- C. Particleboard: ANSI A208.1, Grade M-2-Exterior Glue.

2.2 FABRICATION

- A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."
 - 1. Grade: Custom .
- B. Configuration:
 - 1. Front: Straight, slightly eased at top .
 - 2. Backsplash: Straight, slightly eased at corner .
 - 3. End Splash: Matching backsplash .
- C. Countertops:
 - 1. 3/4-inch- (19-mm-) thick, solid surface material with front edge built up with same material.
- D. Backsplashes: 3/4-inch- (19-mm-) thick, solid surface material.

- E. Fabricate tops with shop-applied edges and backsplashes unless otherwise indicated. Comply with solid surface material manufacturer's written instructions for adhesives, sealers, fabrication, and finishing.
 - 1. Install integral sink bowls in countertops in the shop.
- F. Joints:
 - 1. Fabricate countertops without joints.
- G. Cutouts and Holes:
 - 1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.
 - a. Provide vertical edges, slightly eased at juncture of cutout edges with top and bottom surfaces of countertop and projecting 3/16 inch (5 mm) into fixture opening.
 - b. Provide vertical edges, rounded to 3/8-inch (10-mm) radius at juncture of cutout edges with top surface of countertop, slightly eased at bottom, and projecting 3/16 inch (5 mm) into fixture opening.
 - c. Provide 3/4-inch (20-mm) full bullnose edges projecting 3/8 inch (10 mm) into fixture opening.
 - 2. Counter-Mounted Plumbing Fixtures: Prepare countertops in shop for field cutting openings for counter-mounted fixtures. Mark tops for cutouts and drill holes at corners of cutout locations. Make corner holes of largest radius practical.
 - 3. Fittings: Drill countertops in shop for plumbing fittings, undercounter soap dispensers, and similar items.

2.3 INSTALLATION MATERIALS

- A. Adhesive: Product recommended by solid surface material manufacturer.
 - 1. Adhesives shall have a VOC content of 70 g/L or less.
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Sealant for Countertops: Comply with applicable requirements in Section 07 9200 "Joint Sealants."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates to receive solid surface material countertops and conditions under which countertops will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of countertops.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install countertops level to a tolerance of 1/8 inch in 8 feet (3 mm in 2.4 m), 1/4 inch (6 mm) maximum. Do not exceed 1/64-inch (0.4-mm) difference between planes of adjacent units.

- B. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
- C. Fasten subtops to cabinets by screwing through subtops into cornerblocks of base cabinets. Shim as needed to align subtops in a level plane.
- D. Secure countertops to subtops with adhesive according to solid surface material manufacturer's written instructions. Align adjacent surfaces and, using adhesive in color to match countertop, form seams to comply with manufacturer's written instructions. Carefully dress joints smooth, remove surface scratches, and clean entire surface.
- E. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.
 - 1. Install metal splines in kerfs in countertop edges at joints[**where indicated**]. Fill kerfs with adhesive before inserting splines and remove excess immediately after adjoining units are drawn into position.
 - 2. Clamp units to temporary bracing, supports, or each other to ensure that countertops are properly aligned and joints are of specified width.
- F. Install backsplashes and end splashes by adhering to wall and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears.
- G. Install aprons to backing and countertops with adhesive. Mask areas of countertops and splashes adjacent to joints to prevent adhesive smears. Fasten by screwing through backing. Predrill holes for screws as recommended by manufacturer.
- H. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.
 - 1. Seal edges of cutouts in particleboard subtops by saturating with varnish.
- I. Apply sealant to gaps at walls; comply with Section 07 9200 "Joint Sealants."

END OF SECTION

SECTION 13 3100 – SPECIAL STRUCTURES**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

- A. Drawings and general provisions of the Contract, including General and supplementary Conditions and Division-1 Specification sections, apply to this section.

1.2 SUMMARY OF WORK

A. Project Identification and Description of Work

- 1 The Arabian Leopard Habitat (East & West) and transfer bridge Enclosures (Project) is comprised of site survey, coordination, shop drawings, fabrication and installation of a permanent SS mesh structure supported by steel arches. The Project is comprised of steel arches, mesh covering, cable hardware and interface hardware.
- 2 TYLin will provide Construction Documents to the Specialty Contractor for the development of shop drawings, means and methods, installation sequence diagrams and quality control guidelines as defined in this specification. In addition, the selected Specialty Contractor will be responsible to co-ordinate with all associated trades i.e. Artificial rock work, concrete posts, anchors, foundations etc.
- 3 The Specialty Contractor will be the single source of responsibility for the mesh enclosures and is responsible for the fabrication of all components of the structure, including but not limited to, steel arches, hardware, base plates, interface rods, mesh, cables, etc. Prior to commencement of work a full site survey of existing conditions is required; the selected Specialty Contractor is to coordinate with the project architect and engineer to confirm location of all points of interface. A follow up site meeting will be required to confirm survey prior to commencement of fabrication.

B. SCOPE OF WORK

1. The work consists of furnishing all plant, labor, materials, facilities and equipment required to manufacture, deliver, and install this project on the site provided by the Owner and in so doing demonstrating that the structure is fit for the purpose intended. The work outlined by these plans and specifications consists of the following general requirements:
 - a. Fabrication / Installation Scope.

Fabrication, shipping and installation of the mesh structures includes, but is not limited to the following:

 - 1) Steel members: Arches, and all steel and mesh interface details.
 - 2) Hand woven SS steel mesh, as per specifications.
 - 3) Cables:
 - 4) Hardware – link assemblies and related fasteners, gaskets, cables, etc.
 - 5) Access ways, with all related hardware
 - 6) Interface hardware i.e rods, cables etc
 - 7) Access openings i.e framing, door, hardware, hinges, locking, exiting hardware etc.

- b. All submittals as listed in section 1.7.

1.3 COORDINATION AND RESPONSIBILITY

- A. The Specialty Contractor is to coordinate all work with the Owner, plus any sub-Specialty Contractors and vendors, to ensure compatibility where components relate.
- B. The Specialty Contractor shall coordinate all work with architectural and structural drawings. Conflicts in dimension and interference shall be reported immediately to TYLin prior to commencement of shop drawings.
- C. Construction Documents describing the work herein are as listed as follows:
 - 1. Loading Criteria
 - 2. Drawings

1.4 REFERENCES

- A. 2024 International Building Code (IBC)
- B. American Institute of Steel Construction (AISC)
 - 1.AISC 360-16 "Specification for Structural Steel For Buildings" Latest Edition.
 - 2.AISC 303 "Code of Standard Practice for Steel Buildings" Latest Edition.
- C. American Society of Civil Engineers (ASCE)
 - 1.ASCE 7-22 "Minimum Design Loads For Buildings and Other Structures".
 - 2.ASCE 19-16: Structural Applications of Steel Cables for Buildings
 - 3.ASCE 55-16 Tensile Membrane Structures
- D. Aluminum Construction Manual Series" Aluminum Association Inc., Latest Edition.
- E. American Society for Testing and Materials (ASTM)
 - 1.ASTM A586 "Standard Specification For Zinc-Coated Parallel And Helical Steel Wire Structural Strand", Latest Edition.
 - 2.ASTM A603 "Standard Specification For Zinc-Coated Steel Structural Wire Rope", Latest Edition.
 - 3.ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials
 - 4.ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings
 - 5.ASTM E136 "Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees
- F. The Code For Welding In Building Construction By The American Welding Society (AWS

D1.1), Latest Edition.

G. AISI Specification For The Design Of Cold-Formed Steel Structural Members, Latest Edition.

H. ACI "Building Code Requirements for Reinforced Concrete (ACI 318)", Latest Edition.

I. SSPC: Steel Structures Painting Manual, Volume 2, Systems and Specifications, Latest Edition.

1.5 SYSTEM REQUIREMENT

A. General: Provide a Mesh enclosure system that complies with requirements specified herein.

B. Building Code Criteria: The Mesh Enclosure shall comply with the 2024 International Building Code (IBC)

1. Nominal Ice Thickness: 1.0 in
2. Roof Live Load 5 psf
3. Basic Wind Speed: 115 mph
4. Wind Load Importance Factor: 1.0
5. Wind Exposure Category: B
6. Design Mean Roof Height(s): 50 feet

1.6 QUALITY ASSURANCE

A. Approved Specialty Contractors

1. Birdair: Lawrence Bell Dr. Suite 100, Amherst, NY 14221 (716) 633-9500 Attn: David Capezzuto dcapezzuto@birdair.com
2. Fabritecture, +1 913-488-4317 Attn: Bart Dreiling bart@fabritecture.com
3. Structurflex Inut Street, Suite 201, Kansas City, Missouri 64106 (816) 889-9000 Attn: Tim McFadden tmcfadden@structurflex.com

B. Materials

1. All material shall be of new/first class quality, suitable for the purpose specified, and shall comply with appropriate National Standards, where such exist, unless otherwise specified.

2. Workmanship: All workmanship shall be of the best quality, suitable for the purpose specified and shall comply with the local city code and the appropriate National Standards or Codes of Practice, where such exist, unless otherwise required.
3. Defective Work
 - a. Where in the opinion of TYLin the materials or workmanship of any part of the finished work do not comply with all relevant requirements of this specification, that part shall be classified as defective.
 - b. All work classified as defective shall be replaced to the approval of TYLin at the expense of the Specialty Contractor.
 - c. The extent of the work removed and methods of removal and replacement of this work shall be in accordance with the Owner's instructions. The Specialty Contractor shall pay for any specialist testing required by TYLin in connection with remedial work.
 - d. Sub-letting: The tensile structure Specialty Contractor shall sublet no work without prior approval.

1.7 SUBMITTALS

- A. General: All submittals shall be made to Smith Group.
- B. A schedule of all submittals and major project milestones required for the completion of the project to be submitted within one week of the start of the contract.
- C. Shop Drawings
 1. The Specialty Contractor is responsible for preparing shop drawings based on design drawings for all components including structural steelwork, connections, connection hardware, end fittings, mesh details and interface attachments.
 2. As part of the shop drawings, the Specialty Contractor shall prepare erection and installation sequence drawings fully explaining hoisting and lifting mechanism, location of motors, electrical requirements and other material necessary for the full coordination of the work with other portions of the project.
 3. These drawings shall be submitted to TYLin for approval.
 4. The Specialty Contractor shall allow 14 days for initial review of the submittal and sufficient time to make amendments.
 5. Approval of shop drawings will not relieve the Specialty Contractor of his responsibility for dimensional coordination.
 6. The Specialty Contractor shall obtain authorization to start fabrication based on shop drawing review.
 7. The Specialty Contractor shall be responsible for any of the discrepancies, errors or omissions in the drawings, calculations and other particulars supplied by him, whether or not such drawings have been approved by the Owner or TYLin.

8. Specialty Contractor will provide testing to demonstrate that the Enclosure:
 - a. Resist local wind load conditions
 - b. Additional tests as required by Engineer of Record, Owner or Local Law.

D. Quality Assurance Submittals

1. Testing and inspection of specific structural and system components including:
 - a. Welds
 - b. Slip critical bolted connections
 - c. Paint applications
2. Material and finish samples for approval
3. Material Certificates
 - a. The Specialty Contractor shall submit such technical literature, test certificates or similar declarations as to proof of compliance of the proposed material with all specified performance data or applicable national standards and codes.
 - b. The Specialty Contractor shall submit the following test certificates for components including, but not limited to the following, unless otherwise approved by the Engineer of Record:
 - 1) Steel
 - 2) Stainless Steel Mesh
 - 3) Cables
 - 4) Fasteners
 - 5) Gaskets
 - 6) Miscellaneous items
 - 7) Doors, hardware etc
4. Warranty: Project Warranty documents as described herein
5. Record Documents: Project record documents for installed materials in accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.
6. Maintenance manual: Submit two (2) copies of a maintenance manual for the mesh structure to the Owner. The manual shall include a schedule for routine inspection, an inspection checklist, instructions for emergency repair and use of emergency repair materials, and warranty. During the system erection period, the Owner shall provide maintenance personnel to be trained in the use of the repair materials.

1.8 SUBSTITUTIONS

- A. No variations to the specifications or drawings may be made without approval of TYLin.
- B. The Specialty Contractor shall submit details of and reasons for any proposed variations from this specification, the drawings, and/or TYLin's written or drawn instructions.
- C. In making request for substitution, the Specialty Contractor represents he has personally investigated the proposed product or method and determined that it is equal or superior in all respects to that specified unless such requirements are waived by the Owner. He will provide the same guarantee for substitution as for the product or method specified.

- D. The Specialty Contractor shall coordinate installation of accepted substitutions into the work and complete it in all respects. He waives all claims for additional costs or time extensions related to substitutions. He is responsible for all fabrication delays necessitated because of product substitution, and any additional costs, which accrue to the Owner as a result of these delays.
- E. Should the Specialty Contractor find at any time that the existing conditions make modifications in requirements necessary; he shall promptly report such matters to TYLin for consideration and comment.

1.9 WARRANTY

- A. All fabricated components will be warranted for a period of 10 years for material failure and workmanship. Warranty to cover full replacement and installation costs.

1.10 INSPECTIONS

- A. The Specialty Contractor shall make provisions to have Key Personnel attend inspections along with the Designer & Engineer, and an appropriate representative of the Owner at the Owner's discretion.
- B. The Specialty Contractor attending these inspections will be prepared to undertake all required adjustments to the satisfaction of TYLin.
- C. The Specialty Contractor shall provide 14 days notice for inspections. TYLin or any representative of the Owner may visit the site or inspect supplier's work at any reasonable time.
- D. Where in the opinion of TYLin, materials or workmanship of any part of the finished work do not comply with requirements, that work shall be classified as defective and immediately replaced by the Specialty Contractor at no additional cost to the Owner.

1.11 ERRORS AND OMISSIONS

- A. Any approval given by the Owner in pursuance with this specification shall not be deemed in any way to relieve the Specialty Contractor of any of his liabilities, obligations or responsibilities under the Conditions of this Contract. Errors or omissions in executed work, Specialty Contractor's workshop drawings or any other part of the Specialty Contractor's work shall remain the responsibility of the Specialty Contractor whether approved by the Owner or not.

PART 2 - MATERIALS

2.1 STEELWORK

- A. Submittals
 - 1. The Specialty Contractor shall submit shop and erection drawings for all steelwork components, in accordance with Part 1 General Section 1.7 Submittals.
 - 2. No fabrication of steelwork, under any circumstances, shall commence without approved shop drawings. The Specialty Contractor shall be responsible for all changes required if fabrication proceeds without approved shop drawings for primary metalwork or connections.

- ## B. Materials

- ### C. Finishes

- #### D. Painting

- | | |
|--|---|
| National Zoological Conservation Biology Institute (NZCBI)
Construct Arabian Leopard Facility (ALF)
[SPECIAL STRUCTURE] | Phase 2 – Habitat & Care Building
65% Construction Documents
[13 3100] - 7 |
|--|---|

- a. Shop Applied Primer: 90-97 Tnemec-Zinc @ 2.5 to 3.5 mils dry film thickness.
- d. Shop Applied Intermediate: Series 27 FC Typoxy or N69F Epoxoline II @ 3.0 to 5.0 mils dft in a color recommended by the manufacturer as appropriate under the top coat color.
- e. Shop Applied Topcoat: Series 1075 Endura-Shield, 2 part polyurethane @ 2.0 to 4.0 mils dry film thickness

E. Quality Control and Inspection

- 1. All coatings, when cured, shall be visibly free of dust, dirt, flow lines, streaks, sags, holidays, blisters, pin-holes, runs, curtains or other surface imperfections. Applicator shall follow manufacturer's guidelines for quality control testing on a prescribed schedule during productions.
- 2. Unacceptable color or film characteristics shall be cause for rejection of the entire coated section, and shall be replaced by another factory applied coated section. Determination of such conditions and final approval are to be made by TYLin.
- 3. After erection, clean exposed surfaces of field connections, unpainted areas adjacent to field connections and damaged areas in the shop coat to the same standards as required for the shop coat and paint with the same primer used in the shop coat. Color of the shop coat shall be as recommended by the paint manufacturer to be a suitable undercoat for the finish color selected by TYLin.

F. Fabrication

- 1. Mill column and bearing stiffeners to give full bearing over cross section. Plane contact surface of bearing plates.
- 2. Drill or punch holes at right angles, unless otherwise noted, to the surface of the metal, not more than 1/8 inch larger than connector diameter. Do not make or enlarge holes by burning. Drill material having a thickness in excess of the connector diameter and material thicker than 7/8 inch. Holes shall be clean-cut without torn or ragged edges. Remove outside burrs resulting from drilling operations.
- 3. Provide holes in members to permit connection of the work of other trades. Use suitable templates for the proper location of these holes. Steel requiring adjustment shall be provided with slotted holes as shown.
- 4. Provide holes, slots and openings required by other trades together with necessary reinforcing as shown. Use suitable templates for proper location of these openings. Where openings are shown on the drawings or shop drawings, no change in location will be permitted without prior approval.
- 5. Manual oxygen cutting shall be done only with a mechanically guided torch. Alternatively, an unguided torch may be used at the discretion of TYLin, provided the cut is within 1/8 inch of the required line and the final removal is completed by grinding to produce a surface quality equal to that of the base metal edges. The use of oxygen-cut holes for bolted connections will under no circumstances be permitted, and violation of this clause will be sufficient cause for the rejection of any pieces in which oxygen cut holes exist.
- 6. Provide proper sealing of all welded connections and other connections so as to prevent water migration through all connections.

G. Connections

1. All connection shall be designed for maximum capacity of the member, and shall withstand frequent and constant use unless otherwise detailed and shall be one of the following:
 - a. High-strength bolts/pins.
 - b. Welds.
2. Bolted Connections
 - a. Bolts shall be of a length that will extend not less than 1/4 inch beyond the nuts. Enter bolts into holes without damaging the thread.
3. Welded Connections
 - a. Do not begin structural welding until joint elements are bolted or tacked in intimate contact and adjusted to dimensions shown on Drawings, or both, with allowance for any weld shrinkage that is expected. Weld heavy sections and those having a high degree of restraint with low hydrogen type electrodes. No members are to be spliced without prior review by the Engineer.
 - b. Welding shall be performed by operators who have qualified within the preceding one year period under AWS standard qualifications procedure for the type of work required.

H. Testing

1. Testing and inspection of specific structural steel components including, but not limited to, welded and bolted connections will be performed by the Specialty Contractor, or their representative. The results shall be documented into a submittal for approval by SmithGroup.
2. Inspection and testing of welding work shall consist of visual inspection and non-destructive (LP or MT) spot testing at the rate of at least one test in three welds by each welder.
3. Welds: The testing agency shall perform all tests and inspections in accordance with "The Code For Welding In Building Construction By The American Welding Society (AWS D1.1)", Latest Edition. The following tests for welded connection are required:
 - a. 33% of all shop welds
 - b. 100% of all full penetration welds
 - c. All field welds.
4. High Strength Bolted Connections: The testing agency shall make all test and inspections in accordance with AISC "Specifications for Structural Joints Using ASTM A325 or A490 Bolts."
5. The Specialty Contractor shall provide the testing agency with the following:
 - a. Documents required under Paragraph "Submittals."
 - b. Full and ample means and assistance for testing all material
 - c. Proper facilities for inspection of the work in mills shop and field.
6. Each person installing a connection shall be assigned an identifying symbol or mark and all shop and field connections shall be so identified so that the inspector can refer back to the person making the connection.
7. The testing agency shall operate in such a way that fabrication and erection are not unnecessarily delayed or impeded, and as follows:
 - a. Non-destructive testing shall be by the magnetic particle or ultra-sonic method; whichever is more effective for the joint to be tested unless the method to be used is specifically noted on the drawings.
 - b. Weldments and bolt connections that are found deficient by the testing agency shall be redone or corrected as directed, at the Specialty Contractor's expense and to the satisfaction of the testing engineer.

- c. Where inspection reveals defects, the extent of inspection will be increased as much as necessary to assure that the full extent of the defects in a joint have been found and to assure that the same defects are not present in welds made on similar parts or under similar circumstances.
- d. Work that is not acceptable will be designated by "Repair" or "Reject," as applicable.
- e. Shop welds will be inspected in the shop before the work has a protective system applied or is approved for shipment.
- f. The Inspector will maintain a daily record of the work he has inspected and its disposition. Reports of tests will be made in form prescribed in the "Structural Welding Code." One (1) copy of each of the reports will be submitted to the Engineer on a weekly basis.

I. Product Handling

- 1. Do not handle structural steel until paint has thoroughly dried. Care shall be exercised to avoid abrasions and other damage.
- 2. Stack material out of mud and dirt and provide for proper drainage. Protect from damage or soiling by adjacent construction operations.

J. Architecturally Exposed Structural Steel

- 1. All steel exposed to view shall be Architecturally Exposed Structural Steel.
- 2. Lines shall be straight, surfaces flat and without surface imperfections, corners square and with uniform and sharp arris.
- 3. All welds shall be ground smooth to match surrounding surfaces; flush welds shall blend with adjacent surfaces.
- 4. Tolerances, as a minimum, shall be consistent with the AISC tolerances for Architecturally Exposed Structural Steel, Section 10 of the Code of Standard Practice, except where more stringent tolerances are required by the design.
- 5. Tolerances for fabrication and installation shall be half those normally acceptable for structural steel.
- 6. Surfaces shall be blast cleaned and receive the finish specified herein.

2.2 CABLES

A. Wire Rope/Spiral Strand

- 1. All cables to have Class A zinc coating throughout, and have a PVC jacket unless otherwise specified or approved.
- 2. Unless noted otherwise on the drawings the wire rope construction shall be 6 x19 right hand ordinary lay with wire rope core, complying with the recommendations of ASTM A603 "Standard Specification For Zinc-Coated Steel Structural Wire Rope", Latest Edition.
- 3. Where required, steel spiral strand rope shall comply with the recommendations of ASTM A 586 "Standard Specification For Zinc-Coated Parallel And Helical Steel Wire Structural Strand", Latest Edition.
- 4. The cable construction shall provide the MBL if shown on the drawings. The cable sizes shown on the drawings are based on the standards set in ASTM A603 "Standard Specification For Zinc-Coated Steel Structural Wire Rope".
- 5. Cables designated to be pre-stretched shall be prestretched according to ASTM A603 for wire rope and A586 for spiral strand. Cables of the same type shall have the same modulus of elasticity.
- 6. The Specialty Contractor shall determine the construction stretch of the cables by load cycling from 10% to 45% of the MBL until no inelastic stretch is noted. The construction stretch is measured at 15% MBL. Test results shall be sent to TYLin for approval.

7. All cables shall be manufactured to the following length tolerances (measured at 70 degrees F):
 - a. Length less than 70 ft. 1/4 in.
 - b. Length 70 to 270 ft. 0.03%
 - c. Length greater than 270 ft. 1 in
8. The design of fittings assumes that the cable strength is reduced by not more than 10% at bends of internal radius of 4 x cable diameter. Any variation of the cable construction to achieve this flexibility shall be at the Specialty Contractor expense.
9. Cables shall have a continuous longitudinal paint stipe (1/4" wide max.) along their top surface unless noted otherwise.
10. All swaged and splattered fittings shall be designed and attached to develop the full breaking strength of the cable.
11. All cables shall be delivered clean, dry and free of grease.

2.3 CONNECTORS

- A. Verification: The Specialty Contractor shall verify that all assemblies and hardware fit.
- B. Bolts and threaded studs: refer to project drawings.
- C. Nuts and washers: refer to project drawings.
- D. Anchor Bolts: refer to project drawings.
- E. Spares: The Specialty Contractor shall supply 5% spares for all bolts and fittings delivered loose to the site or as otherwise directed by the Owner.

2.4 STAINLESS STEEL MESH

- A. Submittals
 1. Name of mesh manufacturer and technical literature including standard testing procedures.
 2. One square yard of each type of mesh.
- B. Mesh Description
 1. Material: Type 304 stainless steel 7x7 wire rope handwoven.
 2. Cable diameter x Mesh aperture Dimensions - 1/18 " x 2" x 2"
 3. Finish: black oxide
 4. Breaking Strength - 1/16" diameter **480 lbs or greater**

PART 3- EXECUTION

3.1 GENERAL

- C. Shop Drawings: The Specialty Contractor shall design, prepare and submit to TYlin a complete set shop drawings as appropriate, at least 8 weeks prior to start of fabrication for:
 1. Mesh and supporting metalwork based on TYlin drawings and final cutting patterns.
 2. All connections of unique geometric conditions.
 3. Method of fabrication
 4. Welding procedures and details, including tack and sealing welds
 5. Marking and numbering systems for cables
 6. All information necessary for fabrication of mesh

7. Size, shape and weight of mesh panels, type and location of shop and field connections, and size and type of seams

D. Geometry

1. TYlin to furnish a 3d design intent model to the Specialty Contractor.
2. Specialty contractor to undertake patterning, develop geometry drawing and final 3d extruded model of all components i.e steel, mesh, cables, hardware etc. .These will be submitted by the Specialty Contractor and to Tylin for review and approval.
3. All edge and corner detailing will be indicated on these drawings

E. Approval of Specialty Contractors Drawings

1. The Specialty Contractor shall be responsible for any of the discrepancies, errors or omissions in the drawings, calculations and other particulars supplied by him, whether such drawings have been approved by the Owner or not.

F. Shipment of Work

1. The Specialty Contractor shall advise the Owner of intended date of shipments to site of cables, membranes and steelwork in such a way that inspection may take place prior to shipment.

G. Notice for Inspection

1. The Specialty Contractor shall give seven working days notice for any inspection but the Owner or his appointed representatives shall have the right to visit the Specialty Contractor's or his supplier's works at any reasonable time for purposes of inspection.

3.2 DELIVERY, STORAGE, HANDLING

- A. In order to facilitate inspection at all stages, the work shall always be laid out in separate holding areas and kept clean. All painted or metal coated work shall be supported clear of the ground. Individual member marking shall be visible when members are stacked.
- B. All bundling, packing, handling and transportation shall be planned and carried out in a manner designed to prevent kinks, abrasions, and any damage to the work and any protective coating.
- C. Care should be taken not to crush kink or otherwise damage wire rope cables, mesh or steel members during storage/handling.
- D. The Specialty Contractor shall mark and identify materials so as to ensure that they are properly used as specified. His proposals for so doing and his proposed cable number system shall be submitted for approval.

3.3 ERECTION – STEELWORK

A. Erection General

1. Check the alignment and elevations of all existing steelwork, existing mast supports and other existing conditions affecting the work before starting erection. Correct any deviations encountered and as required to insure a plumb, true and level installation. Obtain Engineer's approval of methods proposed for correcting errors prior to proceeding with correction and erection.

2. Drift Pins may be used only to align the several parts. They shall not be used in such a manner as to distort or damage the metal.
3. Oxygen cutting of structural steel for "fitting-up" purposes shall not be done except with the prior approval of the Engineer.
4. The use of an oxygen-cutting torch for correction fabrication errors will be permitted only when the member is not under load, and upon acceptance of the Engineer.
5. Make all necessary provisions for temporary bracing and for completion of erection where structural members, permanent cables or mesh are temporarily left out for erection at a later date.

B. Erection Tolerances

1. Individual pieces shall be plumbed, leveled and aligned in accordance with the requirements of the "Code of Standard Practice of Steel Buildings."
2. Dimensions shown on Drawings are based on an assumed design temperature of 70 degrees F. Fabrication and erection procedures shall take into account the ambient temperature range at the time of the respective operations.

C. Erection Details. The Specialty Contractor shall suggest the method of erection and shall submit of the following at least four weeks before starting to erect the steelwork:

1. Detailed method and sequence of erection
2. Erection stresses and lifting points indicated in drawing form.
3. Types of winches or lifting gear stay cables and jacking systems.

D. Field Quality Control: Filed testing and inspection requirements shall comply with Part 2 - Products, "Source Quality Control."

3.4 ERECTION - MESH

- A. Handling: Pre-stressing levels and method of pre-stressing must be performed to the satisfaction of the Engineer. A slow and incremental pre-stress process must be used to ensure no local oversteering during erection.
- B. Remove temporary coverings and protection of adjacent work areas
- C. Clean installed products in accordance with manufacturer's instructions before owner's acceptance. Do not use chlorine-based or abrasive cleaners
- D. Repair/maintenance Manual
 1. The Specialty Contractor shall supply a repair/maintenance instruction manual and repair kit with sufficient tools and materials for use by the Owner in the event accidental damage should occur. Touch up paint should be supplied.
 2. The Specialty Contractor shall demonstrate repair/maintenance methods to Owner.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

END OF SECTION (This is an EOS paragraph style.)

FOR REFERENCE ONLY

SECTION 13 3120 - CABLE SUPPORTED MESH STRUCTURES**PART 1 GENERAL****1.1 SUMMARY**

- A. Section Includes:
1. Provide engineered cable supported wire mesh structure, complete, in place, as shown on the drawings, specified herein, or needed for a complete and proper installation.
 2. Work of this Section Includes the Cable supported Mesh structure and mesh transfer bridge for Jaguars
 - a) Steel supported poles
 - b) Wire rope cable support structure
 - c) Wire mesh fabric
 - d) Wire rope hardware

1.2 RELATED SECTIONS

Section 03 30 00 Cast-in-Place Concrete

- A. Section 03 37 13 Artificial Rockwork
- B. Section 09 94 13 Themed Finishes
- C. Section 32 31 00 Fences and Gates

1.3 SYSTEM DESCRIPTION

- A. Delegated Design:
1. The work of this section requires professional design services or certifications by a design professional employed by the fabricator, and who is not the Consultant.
 2. Complete the design of the support structure, wire rope support system, mesh fabric, and hardware. Maintain the general design concept shown.
 3. Do not change member sizes or alter profiles and alignment, except as outlined in the design processes of this section.
- B. Structural Systems Design:
1. Structural Design:
 - a) Provide the structural engineering design for enclosure structure, wire rope support system, mesh fabric, hardware and all connections.
 - b) Drawings and Calculations:
Provide complete design, calculations, and drawings, prepared and signed in accordance with pertinent provisions of division one of these Specifications
 - c) Licensed Engineer:
Design drawings will be prepared, approved, signed and sealed by a Professional Engineer registered in Washington DC.
 2. General Design Loads:
Design all elements for the following loads:
 - a) Dead loads,
 - b) Live loads due to animals and keeper staff (300 pound minimum concentrated load on overhead mesh or cable)
 - c) Wind loads where applicable, as shown on the Drawings.
 3. Geotechnical Investigations and Recommendations:
 - a) The following geotechnical investigations and recommendations provide the basis for the structural and foundation design of the work of this section:
 - b) Geotechnical Investigation, see Section 02 31 00

4. Foundation Design:
Foundation design is by Engineer-of-Record
 - a) Provide all information required for the EOR to confirm the foundation design shown on the Bid Drawings.
 - b) Clearly identify on the shop drawings the reactions, by load case, and unbalanced loading on the supporting poles.
 - c) Design the foundations to limit movement due to frost heave or soil movement.
- C. Approvals and Permits:
 1. General:
Secure the approval of governmental agencies having jurisdiction prior to submitting for the Consultant's approval.
 2. Building Permits:
Obtain all required permits and approvals for proposed systems.
- D. Performance Standards:
 1. Materials specified herein are intended to establish the standards of quality required for the Work of this Section.
 2. Provide appropriate documentation that all proposed materials meet the specific performance requirements specified below.
 3. All materials and/or completed fabrications must have a twenty (20) year structural service life.
 4. All materials must be capable of resisting the loads and all potential wear and abrasions inherent in their position within the completed exhibits.

1.4 SUBMITTALS

- A. General:
 1. Comply with the pertinent provisions of Sections of 01 30 00 Administrative Requirements.
 2. Within 45 calendar days after the Contractor has received the Owner's Notice to Proceed, submit all items listed below
- B. Design Drawings:
 1. Delegated Design:
 - a) Submit complete drawings accurately showing proposed all of the fabrications and equipment described in this section, prepared in accordance with the following provisions:
 - a) Submit complete drawings accurately showing proposed all of the fabrications and equipment described in this section, prepared in accordance with the following provisions:
- C. Fasteners
 1. General:
 - a) Provide zinc-coated or stainless steel fasteners for exterior use.
 - b) Select fasteners for the type, grade, and class required.
 2. Standards:
All fasteners listed below shall comply with ASTM A307 and as follows:
 - a) Bolts and nuts: Regular hexagon-head type, Grade A.
 - b) High strength bolts: ASTM A325N bearing type and ASTM A325F friction type.
 - c) Stainless steel bolts, screws, studs: ASTM F738M, Type 316.
 - d) Stainless steel nuts: ASTM F836M-91, Type 316.
 - e) Plain washers: Round, carbon steel, complying with Fed Spec FF-W-92.

- f) Masonry anchorage devices: Expansion shields complying with Fed Spec FF-S-325.
- g) Concrete Inserts:
 - 1) Threaded or wedge type, galvanized ferrous castings, either malleable iron ASTM A47 or cast steel ASTM A27.
 - 2) Provide bolts, washers, and shims as required, hot-dip galvanized, ASTM A153.
 - 3) Fastener to be compatible with bolt and installed condition to prevent electrolytic-reaction induced corrosion

D. Grout:

- 1. General:
Provide non-Metallic, non-shrink cement grout, meeting all requirements of ASTM C1107.
- 2. Acceptable Manufacturer:
"SonogROUT" as manufactured by Sonneborn Building Products or approved.
- 3. Provide grout specifically recommended by manufacturer for type of application.
- 4. Pre-mixed, factory-packaged, non-staining, non-corrosive, non-gaseous grout complying with CE CRD-C621.

1.5 SUPPORT STRUCTURE

A. General:

- 1. Conform to the applicable requirements of the standard specifications.
- 2. All materials hot dip galvanized except as specifically indicated otherwise.

B. Structural Members:

- 1. Masts:
 - a) Sizes as shown as shown on the drawings.
 - b) Wall thickness as required by the structural design.
 - c) Galvanized steel.
- 2. Posts:
 - a) Diameter as shown on the drawings.
 - b) Wall thickness as shown on drawings.
 - c) Galvanized steel.

C. Finish:

- 1. Hot dip galvanized after fabrication

1.6 LACING BARS

A. General:

- 1. 12mm diameter galvanized steel bars.
- 2. Form to surfaces as shown on the drawings.
- 3. Attach as shown on the drawing details.

1.7 WIRE ROPE MESH

A. Manufacturers and Installers:

- 1. AthruZ Consulting and Distributing (Sean Stoddard), Tucson AZ, info@athruzconsulting.com, www.athrucages.com, tel: (520) 434-8281.
- 2. International Cordage (Kyle Nichols), incoarz@yahoo.com, www.international-cordage.net, Phoenix AZ, tel: (800) 920-1474.
- 3. Nets Unlimited (Sean Stewart / Kelly Blair), Cave Creek AZ, Kelly@netsunlimited.com, www.netsunlimited.com , tel: (480) 515-1300, (480) 515-1301

B. Wire-Rope Mesh:

- 1. Jaguar Wire Rope Mesh:

- a) Mesh: Hand-woven stainless-steel wire mesh. Woven from 1/8-inch diameter stainless steel wire rope. 2-inch by 2-inch mesh typical openings. Black oxide finish.
- b) Jaguar Wire Rope Mesh training wall: Mesh: Hand-woven stainless-steel wire mesh. Woven from 1/8-inch diameter stainless steel wire rope. 2-inch by 2-inch mesh typical openings. Black oxide finish. Designed with 1" deflection

1.8 DIGGING BARRIER

A. Chain link Mesh:

- 1. Galvanized chain-link Mesh:
 - a) 2"x2"x9 ga.
 - b) Hot-dip galvanized, black polyethylene coated.

1.9 WIRE ROPE ASSEMBLIES

A. Manufacturers

- 1. Wire Rope:
United States Steel (USS), Tiger Brand wire rope, WireCo, Loos & Co, Hackensack, Blue Wave DK or approved equal.
- 2. Hardware: Stainless steel, Color: Black
 - a) The Crosby Group, www.thecrosbygroup.com, Tulsa Oklahoma, Telephone (918) 834-4611.
 - b) Electroline, www.esmet.com, Canton Ohio, telephone (800) 321-0870.
 - c) Jakob Rope Systems, www.jakob.ch, Delray Beach FL, tele: 866 215-1421.

B. Wire Rope Cable, Color: Black:

- 1. Primary Support System:
 - a) Wire rope diameter as required by the system design and as required by the minimum size shown on the Drawings.
- 2. Stainless Steel:
 - a) 7 x 19 or 6 x 19 stainless steel aircraft cable.
 - b) AISI 316 BS MA 29: 1982.

C. Wire Rope Hardware:

- 1. Turnbuckle:
 - a) Jaw and jaw type, hot dip galvanized, diameter of thread as shown, 12-inch take-up typical, Crosby Laughlin, HG-228, or approved equal. Color: Black.
 - b) Cable/Wire Rope Clips: Crosby-Laughlin "Crosby Clips" - size to fit cable shown as manufactured by the Crosby Group, Tulsa, Oklahoma, or approved equal. Color: Black.
 - c) Clevis Socket Assembly: Positive grip wire rope end fitting, forged alloy stainless steel, Electroline GD 131 and 150 or approved equal. Size clevis connections to the steel wire rope diameter. Color: Black.
 - d) Shoulder Eye Bolt: Galvanized forged steel shoulder nut eyebolt. Crosby Laughlin, or approved equal. Color: Black.
 - e) Wire Rope Stops: Zinc coated copper stops, size appropriate for the wire rope cable. Color: Black.

1.10 DESIGN & FABRICATION

A. Design Parameters:

- 1. Fabricate from materials in sizes to achieve the profiles and arrangements shown on the drawings:
- 2. Design to withstand the loads specified in Part 1 of this section.

3. Make necessary allowances for expansion and contraction and movement of structure the structure.
 4. Make allowance for trees that penetrate the structure.
 5. Provide design details for collars at tree trunk penetrations as shown on the drawings. Maximum opening at trunk shall be 50mm (2-inches) in any dimension.
 6. Provide for tree growth and minimize abrasion to bark. Provide details of connections at removable panels as shown on the drawings.
- B. Quality:
1. Conform to the Quality Assurance standards for this work.
 2. Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability of connecting material in the finished product.
 3. Work to dimensions shown or accepted on the Shop Drawings, using proven details of fabrication and support.
 4. Use type of materials shown or specified for the various components of the Work.
 5. Form exposed Work true to line and level, with accurate angles and surfaces and with straight sharp edges.
 6. Ease the exposed edges to a radius of approximately [0.03] inch ([0.8] mm) unless otherwise shown.
 7. Weld metal corners and seams continuously, complying with the recommendations of the standard specifications for this section.
 8. At exposed connections, grind exposed metal welds smooth and flush; match and blend with adjoining surfaces.
 9. Form exposed connections flush and smooth, using concealed fasteners wherever possible.
 10. Provide for anchorage of the type shown. Coordinate with supporting structure. Fabricate and space the anchoring devices to provide adequate support for intended use.
 11. Cut, reinforce, drill, and tap the work as indicated to receive finish hardware and similar items.
 12. Fabricate joints that will be exposed to weather in a manner to exclude water or provide weep holes to evacuate accumulated water.
- C. Support Posts (poles):
1. Provide horizontal and vertical members as shown on the drawings and as required to form a rigid structure without sag or twist.
 2. Close all open tube ends.
 3. Provide drain holes as required for hot-dip galvanizing and seal tight with weld material, ground smooth and painted with zinc-rich paint, afterward.
 4. Connections:
 - a) All internal connections fully welded
 - b) Provide bolted connections to adjacent structure or concrete.
- D. Wire Rope Cable Support Structure:
1. Primary Support System:
 - a) Provide a primary support system of wire rope cables to support the secondary wire rope support system and the wire rope mesh.
 - b) Connect the support masts, ground attachment points, and structures as shown on the drawings and as required for a structural sound, and complete enclosure for the animals.
 2. Secondary Support System:
 - a) Provide a secondary support system to support the wire rope mesh.

- b) Connect the primary wire rope support system cables with a network of parallel, smaller wire rope cables.
 - c) Connect secondary wire ropes to the primary wire ropes with hardware of the smallest, commercially available hardware.
- E. Connectors and Fasteners:
- 1. Provide connectors and fasteners of materials matching the materials to be fastened except where specified otherwise.
 - 2. Provide fastener types and sizes appropriate for size and weight of materials to be fastened and as documented in the shop drawings.
 - 3. Except where otherwise specified provide the following fastener types: Hot dip galvanized, conforming to all pertinent standards of this section.

1.11 FINISHES

A. Shop Painting:

- 1. Shop paint all work of this section, except members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded, and galvanized surfaces, unless otherwise specified, and except stainless steel Work.
- 2. Remove scale, rust, and other deleterious materials before applying shop coat.
- 3. Clean off rust and loose mill scale in accordance with SSPC-SP-1.
- 4. Remove oil, grease, and similar contaminants in accordance with SSPC-SP-1.
- 5. Sand blast to near white metal in accordance with SSPC-SP-10 for ferrous metals to receive zinc rich polyamid epoxy primer.
- 6. Ferrous metals to receive zinc rich polyamid epoxy primer require inspection by Owner prior to priming. Notify Owner 24 hours prior to prime coating.
- 7. Immediately after surface preparation, brush or spray on primer in accordance with manufacturer's recommendations, and at a rate to provide the recommended dry film thickness.
- 8. Use painting methods, which will result in full coverage of joints, corners, edges, and exposed surfaces.
- 9. Apply one shop coat to fabricated metal items; except, apply two shop coats to surfaces inaccessible after assembly or erection. Change color of second coat to distinguish it from the first coat.

B. Galvanizing:

Galvanize all steel following fabrication in compliance with the following specifications:

- 1. ASTM A 153 for galvanizing iron and steel hardware.
- 2. ASTM A 123 for galvanizing rolled, pressed, and forged steel shapes, plates, bars, and strip [0.12] inch ([3] mm) thick and heavier.
- 3. ASTM A 386 for galvanizing assembled steel products.
- 4. All galvanized work to be performed true to line and level as required in shop before delivery to the job site.

C. Field Galvanizing Repair:

- 1. Use a high zinc dust content paint for re-galvanizing welds in galvanized steel, complying with MIL-P-21035.
- 2. Repair in accordance with applicable requirements of ASTM A780.
- 3. Repair in accordance with applicable requirements of AS/NZS 4680.
- 4. Products: "Galvicon" by Galvicon Corp., "Drygalv" by Anchor Brand Co., "Tot-Rust" (with aluminum color added) by Wilbur & Williams Co. or equal.

D. Powder Coating:

1. Shop powder coat all work noted in drawings with a thermoset powder coat.
2. Use abrasive, mechanical, or chemical cleaning to remove deleterious materials before applying shop coat as appropriate for the material being cleaned
3. Clean in accordance with SSPC-SP-1 Solvent Cleaning or other SSPC standard.
4. Clean and prepare surfaces in accordance with AS/NZS 1627 Preparation and Pre-treatment of Surfaces.
5. Apply powder coat to 60 to 80 minimum dry coating thickness as appropriate for powder and color to be applied.
6. Use coating methods, which will result in full coverage of joints, corners, edges, and exposed surfaces.
7. Apply in accordance with ASTM D3451-06 Standard Guide for Testing Coating Powders and Powder Coatings.

1.12 OTHER MATERIALS

- A. Provide other materials, not specifically described but required for a complete and proper installation, as selected by the Contractor subject to the approval of the Owner.
 1. Verify materials selection and sizes.
 2. Verify fabrication and connection details for the fabrications or suggest alternative connection details.
 3. Design system utilizing the system components specified in Part 2 of this specification.
 4. Revise drawings as required by the Owner and resubmit.
 5. Delegated Design Submittals:
Provide all submittals described in Section 01 33 50 as required for the work of this section.
 6. Design Notes and Calculations:
Submit stamped and sealed design notes and calculations, signed and sealed by the Professional Engineer.
 7. Product Data:
 - a) A complete list of materials proposed to be furnished and installed under this Section.
 - b) Manufacturer's specifications and other data needed to demonstrate compliance with specified requirements.
 - c) Manufacturer's recommended installation procedures which, when approved by the Owner, will become the basis for accepting or rejecting actual installation procedures used on the work.
 - d) All stainless steel items require manufacturer's certification of type of stainless steel used.
 8. Shop Drawings:
 - a) Submit fully detailed layout, fabrication, and erection drawings of all materials specified herein for approval.
 - b) Drawings shall show all members, shop cuts, and holes, erection sequences, and tolerances.
 - c) Provide templates for anchor and bolt installation by other trades.
 - d) No fabrication or Work shall be commenced until Shop Drawings have been reviewed and returned to the Contractor.
 - e) Fabricate from reviewed drawings only.
 - f) Provide engineered drawings stamped by a Professional Engineer licensed in the jurisdiction in which the project is located.
 - g) Provide reactions at each reaction location for the tension cables. Include load case and identify the magnitude of the unbalanced load and its direction.

9. Samples:
 - a) Provide a 2'-0" length or square piece of each type, size, finish, and grade of each specified material.
 - b) Provide a sample of each item of hardware specified.

1.13 QUALITY ASSURANCE

A. Standards:

1. Building Codes:
 - a) International Building Code, latest edition, as modified by the local jurisdiction.
 - b) Relevant Building Code for the jurisdiction in which the project is being constructed.
2. Material and Fabrication Standards:
 - a) 'Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings' by AISC, latest edition.
 - b) AISC "Specifications for Design, Fabrication, and Erection of Structural Steel for Buildings", 8th Edition; AISC "Code of Standard Practice";
 - c) AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".
3. American Society for Testing and Materials (ASTM):
 - a) ASTM A27-10, Standard Specification for Steel Castings, Carbon, for General Application
 - b) ASTM A47-99(2009)/A47M-99(2009), Standard Specification for Ferritic Malleable Iron Castings
 - c) ASTM A53-10, Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
 - d) ASTM A123-09/A123M-09, Standard Specification for Zinc (Hot Dip Galvanized) Coatings on Iron and Steel Products
 - e) ASTM A153-09/A153M-09, Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware
 - f) ASTM A500/A500M-10a, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
 - g) ASTM A572-07/A572M-07, Standard Specification for High Strength Low Alloy Columbium Vanadium Structural Steel
 - h) ASTM A780-09/A780M-09, Standard Practice for Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings
4. Welding:
 - a) Perform welding with electric arc process and in accordance with AWS "Code for Arc and Gas Welding in Building Construction."
 - b) Qualify welding processes and welding operators in accordance with AWS "Standard Qualification Procedures".
 - c) Welder shall be certified in conformance with (AWS) (WABO) requirements.
5. Qualifications:
 - a) Established firm or individual with a minimum of five (5) years experience in successfully constructing elements of similar nature to the work of this section.
 - b) Provide resumes for key personnel performing the work.
 - c) Submit references and photographic documentation of previous projects documenting the experience and ability to construct the work of this section.

1.14 PRODUCT HANDLING

A. General:

Comply with the pertinent provisions of Sections of 01 60 00 Product Requirements.

B. Protection:

Use all means necessary to protect the materials of this section before, during, and after installation and to protect the Work and materials of all other trades.

C. Replacements:

In the event of damage, immediately make all repairs and replacements necessary to the approval of the Owner at no additional cost to the Owner.

PART 2 PRODUCTS**2.1 MATERIAL STANDARDS****A. Surface Quality:**

For fabrication of the Work of this Section, which will be exposed to view, use only those materials, which are smooth and free from surface blemishes including pitting, seam marks, roller marks, rolled trade names, and roughness.

B. Carbon Steel:

All materials shall comply with:

1. Steel plates, shapes, and bars: ASTM A36.
2. Steel plates to be bent or cold formed: ASTM A283, Grade C.
3. Steel tubing, hot-formed, welded, or seamless: ASTM A501.
4. Steel bars and bar-size shapes: ASTM A306, Grade 65, or ASTM A36.
5. Cold-finished steel bars: ASTM A108, grade as selected by the fabricator.
6. Cold-rolled carbon steel sheets: ASTM A336.
7. Galvanized carbon steel sheets: ASTM A526, with G90 zinc coating in accordance with ASTM A525.
8. Steel pipe: ASTM A53, type as selected, Grade A, epoxy paint finish unless otherwise noted, Schedule 40 unless otherwise indicated.
9. Steel Bar Grating: ASTM A 569 or ASTM A 36.
10. Structural Steel Tubes: ASTM A-500, Grade B

C. Stainless Steel:

All materials shall comply with:

1. Stainless Steel Tube/Pipe:
 - a) Cold-formed, round, seamless stainless steel tubing complying with ASTM A511, Grade B.
 - b) Schedule 40 or 80 stainless steel pipe, Type 304/304L, ASTM A312
2. Plates and Bars:

Stainless steel conforming to ASTM A480, Type 304/304L.
3. Stainless steel tube:

ASTM A269, Type 316L.
4. Stainless steel rod:

ASTM A564, Type 316L. Class A finish.
5. Stainless steel plate:

ASTM A480, Type 316L. Number 1 finish.
6. Black Oxide finish unless otherwise noted

D. Bronze:

1. Bushings and Thrust Washers:
2. Iron bronze sintered bearings (oil impregnated) ASTM B612-91, Oilite Bronze or equal.

E. Aluminum:

All materials shall comply with:

1. Aluminum tube: Type 5052.
2. Aluminum Sheet: Type 5052-H32 or 6061-T6, 3.2mm (1/8-inch, 8-gauge) minimum thickness.
3. Aluminum Extrusions: In accordance with ASTM B221/B221M, alloy 6063-T6

PART 3 EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Examine the areas and conditions under which doors, frames, and panels are to be installed, and correct conditions detrimental to the proper and timely completion of the Work
2. Do not proceed until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. General:

1. Furnish setting drawings, diagrams, templates, instructions, and directions for installation of anchorages, such as concrete inserts, anchor bolts, and miscellaneous items having integral anchors, which are to be embedded in concrete construction. Coordinate delivery of such items to project site

3.3 INSTALLATION

A. General:

1. Set work accurately at the established lines and levels.
2. Install in strict accordance with approved drawings and actual conditions, true and horizontal or perpendicular, level and square with angles and edges parallel with related lines of the structure.
3. Set support structures accurately in position, plumbed, aligned, and braced securely until permanent anchors are set.

B. Shop Drawings:

1. Install the work of this Section in strict accordance with the reviewed Shop Drawings

C. Anchor Bolts:

1. Properly locate and build into the connecting work
2. Preset bolts and anchors using templates or such other methods as may be required to locate the anchors and anchor bolts accurately.

D. Loose Bearing and Leveling Plates:

1. Provide loose bearing and leveling plates for steel items bearing on concrete construction, made flat, free from warps or twists, and of required thickness and bearing area
2. Drill plates to receive anchor bolts and for grouting as required.

E. Fastening:

1. General.
 - a) Provide malleable iron washers for heads and nuts, which bear on wood structural connections
 - b) Provide steel washers for all metal and plastic connections.
 - c) Space anchors [1.97] feet ([60] cm) on centers, except where shown otherwise on the drawings.

F. Mesh Panels:

1. Install mesh panels in the maximum possible sizes.

2. Join mesh panels using 'thread' of the same material, diameter, and construction as the mesh.
3. Use basting stitch to attach each mesh opening to the adjacent mesh opening, corner bar, or wire rope.
4. Secure with approved double half hitch knots at maximum 300mm on center to prevent a broken cord from creating a large opening.
5. Install in strict accordance with approved drawings and actual conditions, true and horizontal or perpendicular as the case may be, level and square with angles and edges parallel with related lines of the structure.

G. Mesh Digging Barriers:

1. Install mesh panels in the maximum possible sizes.
2. Run length of mesh roll horizontally as shown on the drawings.
3. Join mesh panels with stainless steel wire clips.
4. Join wire rope mesh structure and digging barrier panels with 2mm-diameter wire rope and secure with stainless steel wire clips.

3.4 COORDINATION

A. Fences and Gates:

1. Coordinate the work of this section with the closely related work described in Section 32 31 00
2. Coordinate the shop drawings for both sections so that the work of both sections will be coordinated in the field.

3.5 ADJUST AND CLEAN

A. Final Adjustments:

1. Leave Work in complete and proper operating condition.
2. Remove and replace defective Work, including structure, hardware, or fabric which is damaged.

B. Finishes:

1. Painted Finish: Touch up and repair painted finishes with products and procedures that achieve the closest possible match with the shop applied finish.
 - a) Installation

END OF SECTION

SECTION 21 1300 - FIRE SPRINKLER[AND STANDPIPE] SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Description of Work: Furnish all new materials and labor for the detailed design and installation of new automatic fire sprinkler systems as outlined in Design Drawings, hereafter referred to as the "Systems" in complete compliance with this Specification, Contract Drawings, and all applicable codes and standards.
- B. Contract drawings are for information only to show potential system arrangement. Contractor shall field verify all site conditions and information contained on the contract drawings and is responsible for the complete design and installation of the systems in accordance with the specifications. The contract drawings may not show all information necessary for installation of the systems but are intended to be used by Contractor for the purpose of preparing a bid. The contract drawings indicate the following:
 - 1. Approximate pipe routing and sizes.
 - 2. Location of the new riser(s) for the Systems, and major points on the system, such as the fire department connection(s).
- C. Section Includes:
 - 1. Pipes, fittings, and specialties.
 - 2. Fire-protection valves.
 - 3. Sprinklers.
 - 4. Alarm devices.
 - 5. Manual control stations.
 - 6. Identification signs.
 - 7. Escutcheons.

1.2 DEFINITIONS

- A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig (1200 kPa), but not higher than 300 psig (2070 kPa).
- B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at a maximum working pressure of 175 psig (1200 kPa).
- C. AHJ: Authority Having Jurisdiction.
- D. FM: Factory Mutual Global.
- E. UL: Underwriters Laboratories.

1.3 INTENT OF SPECIFICATION

- A. The work performed pursuant to these specifications is to be complete in every respect, resulting in the Systems installed in accordance with the applicable codes, standards, manufacturers' recommendations, and UL listings.

- B. Commencement of Work:
 - 1. No work shall be performed until shop drawings, calculations, and data sheets have been approved by Architect and Engineer. The contractor is solely liable for any work performed prior to this approval.
- C. Upon completion of this work, and as a part of this contract, provide Owner with:
 - 1. Complete information and "as-built" record drawings describing and depicting the entire system as installed, including all information necessary for maintaining, troubleshooting, and/or expanding the system at a future date.
 - 2. Complete documentation of system testing in accordance with NFPA 13 and AHJ's acceptance.
 - 3. Certification that Contractor's work has been inspected and tested, is installed entirely in accordance with the applicable codes, standards, manufacturers' recommendations and UL listings[and FM approvals,] and is in proper working order. Contractor shall use "Contractor's Material and Test Certificate(s)" as required by NFPA 13.

1.4 SYSTEM DESCRIPTIONS

- A. Automatic Wet-Type, Class I Standpipe System: The system includes NPS 2-1/2 hose connections and is connected to a permanent water-supply capable of meeting the demand flow and pressure at the most remote hose connection as required by NFPA 14. The standpipe system may be combined with a wet-pipe sprinkler system.
- B. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to the water supply through an alarm valve. Water discharges immediately from sprinklers when they operate. Automatic sprinklers operate when heat melts fusible link or destroys frangible device.

1.5 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design sprinkler and standpipe systems, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated. Refer to Section 01 3573 for design requirements and procedures associated with delegated design.
- B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- C. Sprinkler system design shall be approved by authorities having jurisdiction.
- D. Margin of Safety:
 - 1. Margin of Safety for Available Water Flow and Pressure: 10 percent of the minimum required residual pressure or 10 psig, whichever is greater, including losses through water-service piping, valves, and backflow preventers.
- E. Sprinkler Occupancy Hazard Classifications and Design Criteria: Design systems in accordance with NFPA 13 and the criteria indicated in these specifications and drawings.
 - 1. Ordinary Hazard Group 2:

- a. Definition: Occupancies where the quantity and combustibility of content are moderate to high, stockpiles of contents with moderate rates of heat release do not exceed 12 ft, and stockpiles of contents with high rates of heat release do not exceed 8 ft.
 - b. Minimum Design Area and Design Density: 0.20 gpm/sq. ft. over 1500-sq. ft. area.
 - c. Maximum Protection Area per Sprinkler: 130 sq. ft.
 - d. Maximum Sprinkler Spacing: 15 ft.
 - e. Combined Hose-Stream Demand Requirement: 250 gpm.
 - f. Operation Duration: 90 minutes.
- F. Sprinkler Listing Design Criteria: All sprinklers shall be designed and installed in accordance with the product listing. Alternate design criteria recommended or required by a specific sprinkler listing may be utilized only when the sprinkler is approved for use on this project. Sprinkler listing design criteria approved for use on this project will take precedence over the criteria noted in Section this specification only to the extent indicated by the sprinkler listing.

1.6 ACTION AND INFORMATIONAL SUBMITTALS

- A. General:
- 1. Submittal shall contain all necessary information for the entire system. Partial submittals will not be accepted.
 - 2. Provide submittals, including shop drawings, samples, documentation and record drawings, to the Architect and Engineer to review on behalf of the Owner. This review is to verify conformance to project specifications and design concepts expressed in the contract documents. Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details (i.e., dimensions) or for substantiating installation or performance of equipment or systems designed by the Contractor, all of which remain the Contractor's responsibility to the extent required by the contract documents. The review on behalf of the Owner shall not constitute approval of safety precautions of construction, means, method, techniques, sequences of procedures, approval of a specific assembly of which the item is a part.
- B. Product Data: For each type of product indicated, include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. When a product data shows more than one product, the specific proposed product shall be clearly indicated by arrows or other suitable means. Mark out all inapplicable items. Catalog data must have the item or model number to be provided clearly marked and all accessories indicated. Submit literature showing details of each item of equipment. Plainly indicate the intended use of each item shown. All manufacturers' data sheets shall clearly show all listings and approvals for each product submitted.
- D. Shop Drawings: Provide working drawings in accordance with applicable codes and standards, this specification, and Division 01.
- 1. Include plans drawn to scale, elevations, sections, details, and attachments to other work. Provide diagrams for power, signal, and control wiring.
 - 2. Indicate coordination with other fire-protection or non-fire-protection building systems including, but is not limited to, domestic water piping, compressed air piping, HVAC hydronic piping / ductwork, items penetrating ceiling assemblies, etc.

3. Where permitted for use elsewhere in this specification and provided for this project, flexible sprinkler connections shall be clearly indicated on drawings including locations, manufacturer, length, outlet type, maximum bend radius, maximum number of bends, as well as attachment methods to all ceiling types.
 4. Grooved joint couplings and fittings shall be identified on drawings, including the manufacturer's listed model or series designation.
 5. Sprinklers identification or Model number shall be identified on drawings as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.
- E. Hydraulic Calculations: Prepared according to NFPA 13 and showing the pipe sizes proposed to produce adequate performance. Safety factor required in this specification shall be demonstrated in the hydraulic calculations. Where permitted for use elsewhere in this specification and provided for this project, flexible sprinkler connections shall be included in hydraulic calculations including manufacturer specific equivalent length for flexible connections and any right-angle/elbow fittings used for sprinkler attachment to flexible connections.
- F. Qualification Data: For qualified installer and designer.
- G. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- H. Welding certificates.
- I. Fire-hydrant flow test report: Prepared according to NFPA 13 and NFPA 291. Include site plan indicating location of all flow and test hydrants.
- J. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- K. Field quality-control reports.
- 1.7 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals. At a minimum, the following shall be included:
1. 11-in. x 17-in. reduced copies of the 'as-built' record drawings required below (Final submittal only).
 2. Manufacturers' catalog data sheets and installation manuals for all installed components.
 3. Copy of NFPA 25.
 4. Copy of all test certificates and approvals.
 5. A list of recommended spare parts and summary of spare parts provided.
 6. A service directory, including a list of Contractor's contact names and telephone numbers for service on the system, including emergency service as required elsewhere in these Specifications.

- B. Contractor Record Drawings: Contractor shall provide and maintain on the site an up-to-date 'as-built' record set of approved shop drawing prints which shall be marked to show each and every change made to the sprinkler system from the original approved shop drawings. This requirement shall not be construed as authorization to deviate from or make changes to the shop drawings approved by Owner without written instruction from Owner in each case. These drawings shall be maintained in a current condition at all times and shall be made available for review immediately upon request during normal working hours throughout the installation. Upon completion of the 'as-built' record drawings and before final approval, one set of reproducible 'as-built' record drawings shall be delivered to Owner. Upon approval by Owner, three (3) sets of final record drawings shall be furnished to Owner. In addition, a record set of drawings shall be transmitted to Owner in the AutoCAD format with any applicable executable, un-archiving files.
- C. If Contractor's submittals, upon review by Owner, do not conform to the requirements of these specifications, Contractor shall be required to resubmit with modifications, within ten (10) working days of receipt of Owner's notification to Contractor. Contractor shall be responsible for Owner's expenses for subsequent review of rejected submittals that were necessitated by Contractor's failure to make the requested modifications. Such extra fees shall be deducted from payments by Owner to Contractor.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.9 QUALITY ASSURANCE

- A. All work shall conform to the requirements of the applicable editions and portions of the National Fire Protection Association (NFPA) Standards, locally adopted codes, and this specification.
1. 2024 International Building Code with Local Amendments
 2. 2024 International Fire Code with Local Amendments
 3. NFPA 13 - 2025 edition, Standard for the Installation of Sprinkler Systems
 4. NFPA 24 - 2025 edition, Standard for the Installation of Private Fire Service Mains and Their Appurtenances
 5. NFPA 25 - <insert edition> edition, Standard for the Inspection, Testing and Maintenance of Water Based Fire Protection Systems
 6. NFPA 70 - 2026 edition, National Electrical Code with Local Amendments
 7. NFPA 72 - 2025 edition, National Fire Alarm and Signaling Code
- B. All work and materials shall conform to all Federal, State, and local codes and regulations governing this installation.
- C. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
2. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
3. Contractor Requirements: System design shall be by personnel certified by NICET as Level III Water-Based Systems technician as a minimum. Contractor shall:
 - a. Hold all licenses and obtain all permits necessary to perform work of this type in the District of Columbia. Copies of Contractor's licenses shall be provided with bid submittal.
 - b. Be regularly engaged, for the past 5 years in the design, installation, testing and servicing of automatic sprinkler systems for buildings of this type.
 - c. Have worked on one or more comparable new installation projects in the last five years.
 - d. Contractor's site supervisor will be at the job site at all times when work is actively in progress.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Modifications to Specification: Contractor shall be responsible for the review and compliance with this Specification. All work shall be performed in accordance with the Specification and good engineering and installation practice. Modifications to the Specification will NOT be accepted without the expressed written approval of Owner and/or Architect/Engineer. It is the Contractor's responsibility to document the required approvals of any such modifications prior to the execution of work.
- F. Code Conflicts: Should conflicts exist between the referenced NFPA Standards, Federal, State or local codes and this specification, it shall be Contractor's responsibility to bring the conflict to the attention of Owner for resolution. The contractor shall not attempt to resolve code conflicts with the local authority, independent of Owner. In general, in the event of a conflict, the most stringent of the requirements will apply.
- G. Design Document Conflicts: The sprinkler Contract Drawings and this Specification define the Scope of work for the project. The Contract Drawings are intended to be schematic only, and the Contractor's responsibilities are defined herein. Where conflicts occur between this Specification and Contract Drawings, the contractors shall request clarification prior to bidding. In general, should a conflict occur, the Specification will overrule the Contract Drawings.
- H. Permit Fees: Contractor shall be responsible for filing all documents, paying all fees and securing all permits, inspections and approvals necessary for completing the scope of the work in this section.
- I. The Contractor shall be responsible for the cost to provide and install any additional devices required as part of the plan check and inspection process conducted by the AHJ.

- J. Equipment: All devices, systems, equipment and materials furnished and installed shall be new and shall be submitted for approval by Owner. All sprinklers, pipe, fittings, hangers, valves, and other materials and equipment shall be UL Listed for their intended use. All shall be acceptable to the AHJ when such agencies have listings of acceptable equipment. The equipment and system components shall be installed in accordance with the applicable codes and standards, the manufacturers' recommendations, and within the limitations of the UL listings. All equipment and system components shall substantially be the standard product of a single manufacturer. Evidence of UL listings is required.
- K. Fittings: Fittings may be of the flanged, threaded, or grooved type. Welded outlets on cross-mains for riser nipples and/or branch lines and for sprinkler outlets on branch lines will be permitted. All shall be UL Listed for their intended use. The use of plain-end fittings to join steel pipe is not permitted.
1. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 2. All castings used for couplings housings, fittings, or valve and specialty bodies shall be date stamped for quality assurance and traceability.

1.10 WARRANTY AND EMERGENCY SERVICE

- A. Contractor shall warranty all materials and workmanship for a period of one (1) year beginning with the date of final acceptance of Contractor's completed installation by Owner. Contractor shall be responsible during the design, installation, testing and warranty periods for any damage caused by Contractor (or its subcontractors) or by defects in Contractor's (or its subcontractors') work, materials, or equipment.
- B. Emergency Service: During the installation and warranty period, Contractor shall provide emergency repair service for the sprinkler systems within twenty-four (24) hours of a request by Owner for such service. This service shall be provided on a 24-hour per day, seven days per week basis.

1.11 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.

2.2 STEEL PIPE AND FITTINGS

- A. Schedule 40, Galvanized- Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.

- B. Schedule 10, Galvanized- Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
- C. Galvanized- Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Galvanized, Steel Couplings: ASTM A 865, threaded.
- E. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- F. Malleable- or Ductile-Iron Unions: UL 860.
- G. Cast-Iron Flanges: ASME 16.1, Class 125.
- H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
- I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
- J. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - 2. Pressure Rating: 175 psig (1200 kPa) minimum.
 - 3. Installation-Ready fittings for Schedule 40 grooved end steel piping in sizes NPS 1-1/4 thru 2-1/2 (DN 32 thru DN 65). Fittings shall consist of a ductile iron housing with Installation-Ready ends, prelubricated Grade "E" EPDM Type 'A' gasket; and ASTM A449 electroplated steel bolts and nuts. UL listed for a working pressure of 300 psi (2065 kPa) and FM approved for working pressure 365 psi (2517kPa).
 - 4. Galvanized, Grooved-End Fittings for Steel Piping: ASTM A 536, ductile-iron casting or factory manufactured from ASTM A53 steel pipe; with dimensions matching steel pipe.
 - 5. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, bolts and nuts, EPDM-rubber center-leg gasket with pipe stop to ensure proper groove engagement, alignment, and pipe insertion depths.
 - a. Rigid Type: Housings cast with offsetting, angle-pattern bolt pads to provide rigidity and system support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad offset contact. Couplings that require exact gapping at specific torque ratings are not permitted.
 - b. Flexible Type: For use in locations where vibration attenuation and stress relief are required.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick .
 - 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 - 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Grooved Joint Lubricants: Lubricate gasket in accordance with the manufacturer's published instructions with lubricant approved for the gasket elastomer and fluid media.
- D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

- 1. Valves shall be UL listed or FM approved.
- 2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig (1200 kPa).
- 3. Minimum Pressure Rating for High-Pressure Piping: 300 psig (2070 kPa).
- 4. Unless specified elsewhere in this specification, valve NPS 2 (DN 50) and smaller shall have threaded ends, and NPS 2-1/2 (DN 65) and larger shall have grooved or flanged ends.
- 5. Subject to compliance with requirements, the following manufacturers are acceptable. Approved equal products may be used as substitute.
 - a. Anvil International, Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO Inc.
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Tyco Fire & Building Products LP.
 - f. Victaulic Company.
 - g. Viking Corporation.
 - h. Watts Water Technologies, Inc.

B. Ball Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. NIBCO Inc.
 - c. Victaulic Company.
 - d. Viking Corporation.
- 2. Standard: UL 1091 except with ball instead of disc.
- 3. Valves NPS 1-1/2 (DN 40) and Smaller: Bronze or brass body with threaded or grooved ends.
- 4. Valves NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile-iron body with grooved ends.
- 5. Valves NPS 3 (DN 80): Ductile-iron body with grooved ends.

C. Butterfly Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fivalco Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO Inc.
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Tyco Fire & Building Products LP.
 - f. Viking Corporation.

- g. Victaulic Company.
 2. Standard: UL 1091.
 3. Body Material: Bronze for NPS 2 (DN 50) and smaller. Cast of ductile iron for NPS 2-1/2 (DN 65) and larger.
 4. Seat: Pressure responsive elastomer.
 5. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
 6. End Connections: Threaded, grooved, or flanged.
 7. Supervised butterfly valves shall be provided with an integral tamper switch. Valves to be supervised in the normally closed position shall be listed for normally closed operation. Integral tamper switches shall comply with the requirement of this specification.
- D. Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Milwaukee Valve Company.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - e. Watts Water Technologies, Inc.
 2. Standard: UL 312.
 3. Type: Single swing check or spring-assisted type for vertical installation.
 4. Body Material: Cast ductile iron.
 5. Clapper: Bronze, ductile iron, or stainless steel with elastomeric seal.
 6. Clapper Seat: Brass, bronze, or stainless steel.
 7. Hinge Shaft: Bronze or stainless steel.
 8. Hinge Spring: Stainless steel.
 9. End Connections: Flanged or grooved.
- E. OS&Y Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. Mueller Co.; Water Products Division.
 - c. NIBCO INC.
 - d. Tyco Fire & Building Products LP.
 - e. United Brass Works, Inc.
 - f. Victaulic Company
 - g. Watts Water Technologies, Inc.
 2. Standard: UL 262.
 3. Body Material: Bronze for NPS 2 (DN 50) and smaller. Cast of ductile iron for NPS 2-1/2 (DN 65) and larger.
 4. Wedge and wedge seat: Cast or ductile iron, or bronze with elastomeric coating per valve listing.
 5. Stem: Bronze or brass.
 6. End Connections: Threaded, grooved, or flanged.
- F. Indicating-Type Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Anvil International, Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO Inc.
 - d. Tyco Fire & Building Products LP.
 - e. Victaulic Company.
 2. Standard: UL 1091.
 3. Pressure Rating: 175 psig (1200 kPa) minimum.
 4. Valves NPS 2 (DN 50) and Smaller:
 - a. Valve Type: Ball or butterfly.
 - b. Body Material: Bronze or brass.
 - c. End Connections: Threaded or grooved.
 5. Valves NPS 2-1/2 (DN 65) and Larger:
 - a. Valve Type: Butterfly.
 - b. Seat: Pressure responsive elastomer.
 - c. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
 - d. Body Material: Cast or ductile iron.
 - e. End Connections: Flanged, grooved, or wafer.
 6. Valve Operation: Weatherproof actuator housing with factory installed integral electrical, 125-V ac, prewired, two-circuit, supervisory switches indicating device.
- G. NRS Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or approved equal:
 - a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - b. American Valve, Inc.
 - c. NIBCO INC.
 - d. Tyco Fire & Building Products LP.
 - e. Victaulic Company.
 2. Standard: UL 262.
 3. Pressure Rating: 300 psig (2070 kPa).
 4. Body Material: Cast iron with indicator post flange.
 5. Stem: Non-rising brass or bronze.
 6. Wedge: Cast or ductile iron.
 7. Wedge Seat: Cast or ductile iron, or bronze.
 8. End Connections: Flanged or grooved.
- H. Indicator Posts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Cast Iron Pipe Company; Waterous Company Subsidiary.
 - b. American Valve, Inc.
 - c. NIBCO INC.
 - d. Tyco Fire & Building Products LP.
 - e. Victaulic Company.
 2. Standard: UL 789.
 3. Type: Horizontal for wall mounting.
 4. Body Material: Cast iron with extension rod and locking device.
 5. Extension Barrel: Cast or ductile iron.
 6. Cap: Cast or ductile iron.
 7. Operation: Wrench.

2.5 FIRE DEPARTMENT CONNECTIONS

A. Free-Standing Fire Department Connection:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Elkhart Brass Mfg. Company, Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Potter Roemer.
2. Standard: UL 405.
3. Type: Exposed, freestanding .
4. Pressure Rating: 175 psig (1200 kPa) minimum.
5. Body Material: Corrosion-resistant metal.
6. Inlets: Brass with threads according to NFPA 1963 and matching local fire department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
7. Caps: Brass, lugged type, with gasket and chain.
8. Escutcheon Plate: Round, brass, floor type.
9. Outlet: Bottom, with pipe threads.
10. Number of Inlets: Two.
11. Sleeve: Not required.
12. Sleeve Height: 18 inches.
13. Escutcheon Plate Marking: Similar to "AUTO SPKR."
14. Finish: Polished chrome plated.
15. Outlet Size: NPS 4.

- B. At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing.

2.6 SPRINKLER SPECIALTY PIPE FITTINGS

A. Test and Drain Valve Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

B. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Brass Mfg. Company, Inc.
 - b. Fire-End & Croker Corporation.
 - c. Potter Roemer.

2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa).
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

C. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco Fire & Building Products LP.
 - b. Victaulic Company.
 - c. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

2.7 SPRINKLERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Reliable Automatic Sprinkler Co., Inc.
2. Tyco Fire & Building Products LP.
3. Victaulic Company.
4. Viking Corporation.

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation.
 - a. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss cast in the sprinkler body.
3. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
4. Pressure Rating for High-Pressure Automatic Sprinklers: 300 psig (2070 kPa).

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. Characteristics: Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.

D. Sprinkler Finishes and Special Coating: Factory-applied per Sprinkler Schedule.

E. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers. Refer to Sprinkler Finish Schedule.

F. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

G. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

2.8 ALARM AND SUPERVISORY DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 10-inch diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: NPS 1 (DN 25) drain connection.

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Potter Electric Signal Company.
 - b. System Sensor; a Honeywell company.
 - c. Viking Corporation.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: [Paddle operated][Vane operated][Pressure sensor].
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

D. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell company.
 - b. Potter Electric Signal Company.
 - c. System Sensor; a Honeywell company.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position or other than the full-closed position for normally-closed valves.

E. Indicator-Post Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Potter Electric Signal Company.
 - b. System Sensor; a Honeywell company.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.9 PRESSURE GAUGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AMETEK; U.S. Gauge Division.
 2. Ashcroft, Inc.
 3. Brecco Corporation.
 4. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
- D. Pressure Gauge Range: 0 to 300 psig (0 to 2070 kPa).
- E. Water System Piping Gauge: Include "WATER" or "AIR/WATER" label on dial face.
- F. Air System Piping Gauge: Include "AIR" or "AIR/WATER" label on dial face.

2.10 BACKFLOW PREVENTERS

- A. Double-Check, Detector-Assembly Backflow Preventers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. FEBCO; SPX Valves & Controls.
 - d. Mueller Co.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Wilkins Water Control Products Division.

2. Standards: ASSE 1048 and UL's "Fire Protection Equipment Directory" listing or FM Global's "Approval Guide."
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig (35 kPa) maximum, through middle one-third of flow range.
5. Size: <Insert NPS (DN)>.
6. Design Flow Rate: <Insert gpm (L/s)>.
7. Selected Unit Flow Range Limits: <Insert gpm (L/s)>.
8. Pressure Loss at Design Flow Rate: <Insert psig (kPa)>.
9. Body Material: Steel with interior lining complying with AWWA C550 or that is FDA approved.
10. End Connections: Flanged.
11. Configuration: Designed for vertical flow.
12. Accessories:
 - a. Valves: UL 262 and FM Global's "Approval Guide" listing; OS&Y gate type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

B. Backflow Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. FEBCO; SPX Valves & Controls.
 - d. Flomatic Corporation.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Wilkins Water Control Products Division.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.11 IDENTIFICATION SIGNS AND LABELS

- A. General: Identification signs shall be rigid, metal plaques with embossed enamel background and lettering. Signs shall be secured by chain or durable wire to each sprinkler zone control valve, main and auxiliary drain, and inspector's test valve, etc. System hydraulic calculation placards affixed using adhesives, and/or using permanent marker for information, are NOT acceptable.
- B. Hydraulic Calculation Signs:
 1. Contractor shall furnish and install hydraulic calculation signs for each new sprinkler and standpipe zone. Hydraulic calculation signs shall be affixed to the corresponding system riser downstream of the system control valve and main drain at the riser.
 2. Hydraulic calculation signs shall include all information indicated in NFPA 13 and appendices. Valve identification signs shall identify the function of the valve and the area served.
- C. Equipment Labels
 1. Material and Thickness: [Brass, 0.032 inch (0.8 mm)] [stainless steel, 0.025 inch (0.64 mm)] [aluminum, 0.032 inch (0.8 mm)] [or] [anodized aluminum, 0.032 inch (0.8 mm)] thick, with predrilled holes for attachment hardware.
 2. Letter Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.

3. Background Color: [Black] [Blue] [Red] [White] [Yellow] <Insert color>.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless-steel [rivets] [or] [self-tapping screws].
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Pipe Labels

1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.
2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to [partially cover] [cover full] circumference of pipe and to attach to pipe without fasteners or adhesive.
3. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
4. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - a. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - b. Lettering Size: [Size letters according to ASME A13.1 for piping] [At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances].
5. Pipe-Label Colors:
 - a. Background Color: Safety Red.
 - b. Letter Color: White.

E. Stencils

1. Lettering Size: [Size letters according to ASME A13.1 for piping] [At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances].
2. Stencil Material: [Aluminum] [Brass] [Fiberboard] [Fiberboard or metal] <Insert material>.
3. Stencil Paint: Safety Red, exterior, gloss, [alkyd enamel] [acrylic enamel] <Insert paint type>. Paint may be in pressurized spray-can form.
4. Identification Paint: White, exterior, [alkyd enamel] [acrylic enamel] <Insert paint type>. Paint may be in pressurized spray-can form.

F. Valve Tags

1. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping-system abbreviation and 1/2-inch (13-mm) numbers.
2. Tag Material: [Brass, 0.032 inch (0.8 mm)] [stainless steel, 0.025 inch (0.64 mm)] [aluminum, 0.032 inch (0.8 mm)] [or] [anodized aluminum, 0.032 inch (0.8 mm)] thick, with predrilled holes for attachment hardware.
3. Fasteners: Brass [wire-link chain] [beaded chain] [or] [S-hook].
4. Valve-Tag Color: Safety Red.
5. Letter Color: White.

6. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - a. Valve-tag schedule shall be included in operation and maintenance data.

2.12 ESCUTCHEONS

- A. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- B. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.13 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.14 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.15 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. Metraflex Company.
 4. Pipeline Seal and Insulator, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 2. Pressure Plates: Stainless steel.
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.16 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Presealed Systems.
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.17 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for sprinkler piping and connections to verify actual locations of piping connections before installation.
- B. Examine walls and partitions for suitable thickness, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections/stations, sprinklers, and piping are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Perform fire-hydrant flow test in accordance with NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.
- C. Coordinate with other trades.
- D. Obtain owner's approval for all openings or penetrations.
- E. Obtain final approval of design documents prior to installation.

3.3 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas [2 inches (50 mm)] above finished floor level.
 - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.4 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Division 07 Section "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.5 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.

- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.6 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.7 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel wall sleeves with sleeve-seal system .
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 2. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than [NPS 6 (DN 150)] <Insert pipe size>: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Sleeve-seal fittings] <Insert material>.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping [NPS 6 (DN 150)] <Insert pipe size> and Larger: [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves] <Insert material>.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Interior Partitions:
 - a. Piping Smaller Than [NPS 6 (DN 150)] <Insert pipe size>: [Galvanized-steel-pipe sleeves] <Insert material>.
 - b. Piping [NPS 6 (DN 150)] <Insert pipe size> and Larger: [Galvanized-steel-sheet sleeves] <Insert material>.

3.8 ESCUTCHEON INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - 2. Escutcheons for Existing Piping:
 - a. Insulated Piping: Split-plate, stamped-steel type with hinge.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.
- E. Replace broken and damaged escutcheons and floor plates using new materials.

3.9 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.

3.10 WATER-SUPPLY CONNECTIONS

- A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 22 1116 "Domestic Water Piping."

- B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-distribution piping.
- C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water supply.

3.11 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.
- C. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- D. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
- E. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
- F. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- G. Install sprinkler piping with drains for complete system drainage.
- H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- I. Install automatic (ball drip) drain valve at each check valve for fire department connection, to drain piping between fire department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- J. Install alarm devices (e.g., flow switches) in piping systems.
- K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- L. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each riser. Include pressure gauges with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they will not be subject to freezing.
- M. Fill wet-pipe sprinkler system piping with water.
- N. Install sleeves for piping penetrations of walls, ceilings, and floors.
- O. Install sleeve seals for piping penetrations of concrete walls and slabs.

- P. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.12 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- I. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts in accordance with the manufacturer's latest published instructions. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts in accordance with the manufacturer's latest published instructions. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. Factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

3.13 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13, manufacturer's instructions, and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the pipe center.
- F. Install valves in position to allow full stem movement.
- G. Install valve tags. Comply with requirements in this specification for Identification Signs and Labels for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.
- H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections.
- I. Supervisory Switches: Install supervisory switches for sprinkler control valves to monitor closure of the valve and for high and low system supervisory nitrogen pressure to monitor abnormal system pressures.

3.14 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Do not install sprinklers that have been dropped, damaged, show a visible loss of fluid, or a cracked bulb. The sprinkler bulb protector shall be removable by hand, without tools or devices that may damage the bulb.

3.15 HOSE CONNECTION INSTALLATION

- A. Install freestanding hose connections for access and minimum passage restriction.
- B. Install NPS 2-1/2 hose connections.
- C. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose.

3.16 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install yard-type, fire department connections in concrete slab support. Comply with requirements for concrete in Section 03 3000 "Cast-in-Place Concrete."
 - 1. Install protective pipe bollards around each fire department connection. Comply with requirements for bollards in Section 05 5000 "Metal Fabrications."
- B. Install automatic (ball drip) drain valve at each check valve for fire department connection.

3.17 IDENTIFICATION SIGNS AND LABELS

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13. Identify system components, wiring, cabling, and terminals. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed. Coordinate installation of identifying devices with locations of access panels and doors. Install identifying devices before installing acoustical ceilings and similar concealment.
- B. Equipment Label Installation: Install or permanently fasten labels on each major item of mechanical equipment. Locate equipment labels where accessible and visible.
- C. Pipe Label Installation: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit a view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Valve Identification Sign Installation: Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule. Tag valves according to size, shape, and with captions similar to those indicated below:
1. Wet-Pipe Sprinkler System: 1-1/2 inches (38 mm), round .

3.18 FIELD QUALITY CONTROL

- A. Perform pretests and inspections prior to Final Inspection and Tests.
- B. Pretests and Inspections shall include the following at a minimum:
1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 2. Pretest and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Verify that equipment hose threads are same as local fire department equipment.
- C. Correct all deficiencies identified during pretest and inspection prior to scheduling Final Inspection and Test.

3.19 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

3.20 FINAL INSPECTION AND TEST

- A. Contractor shall make arrangements with Owner for Owner's final inspection and the local authorities.
- B. All tests and inspections required by the referenced Codes and Standards, AHJ, and Owner shall be conducted by Contractor under this scope of work.
1. When AHJ are required to witness tests, Contractor shall be responsible for making all necessary arrangements with the code authorities and coordinating the testing with Owner.
- C. Contractor shall be responsible for completing all test documents with necessary approval stamps and signatures of the AHJ. Contractor shall submit one copy of each of these documents to Owner for their records.
- D. Tests and Inspections:
1. Hydrostatic Test: Hydrostatic tests shall be conducted at the greater of 200 psig or 50 psig above the normal system pressure, whichever is greater, for a two-hour period with no leakage or reduction in gauge pressure. Charge systems and test for leaks. Repair leaks and retest until no leaks exist. Hydrostatic test pressures shall not be maintained on the system overnight. Flush piping with potable water in accordance with NFPA 13.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect standpipe systems according to NFPA 13, "System Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors for dry-pipe and preaction sprinkler systems.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire pump tests. Operate as required.

E. Prepare test and inspection reports.

3.21 FINAL APPROVAL

- A. Final approval and acceptance of the work will be given by Owner when:
1. The completed sprinkler system has been inspected, tested and approved by Owner and AHJ.
 2. Required submittals, system operation and maintenance manuals, record drawings, spare parts, special tools and training have been provided to, reviewed, and accepted by Owner.
 3. Written certification is submitted that states all equipment has been inspected and tested by a manufacturer's certified representative.
 4. Written certification is submitted that states all equipment is installed in accordance with the manufacturer's recommendations and UL and/or FM approvals.
- B. Owner's Representative may visit the job site to observe the work and witness the final acceptance tests when advised by Contractor that the work is complete and ready for test. If the work has not been completed, or the test is unsatisfactory, Contractor shall be responsible for Owner's added expenses for re-inspection and witnessing the retesting of the work. Such extra fees shall be deducted from payments by Owner to Contractor.
- C. Additional Tests: Any additional tests, required by the referenced codes, standards, or criteria, or by Owner, shall be performed.

3.22 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain .
- B. Contractor shall conduct one four-hour training session(s) at the project site to familiarize the building personnel with the features, operation and maintenance of the sprinklers and standpipe. Training sessions shall be scheduled by Owner at a time mutually agreeable to Contractor and Owner.

3.23 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, Schedule 40 steel pipe with threaded ends; cast-iron threaded fittings; and threaded joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 (DN 65) and smaller, shall be the following:

1. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 4 (DN 100) and larger, shall be the following:
 1. Schedule 40 or Schedule 10, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.24 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 1. Rooms without Ceilings: Upright sprinklers.
 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 3. Wall Mounting: Sidewall sprinklers.
 4. Spaces Subject to Freezing: Sidewall, dry sprinklers.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - a. Specialty Ceiling Finishes: Provide manufacturers standard or custom color cover plate as selected by the Architect.
 2. Upright and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION

SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 GENERAL MOTOR REQUIREMENTS**

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Comply with IEEE 841 for severe-duty motors.
- D. Provide a maintenance free, circumferential conductive micro fiber grounding ring installed on the AC motor to discharge shaft currents to ground. Grounding ring shall be AEGIS SGR (Shaft Grounding Ring).
- E. Motors protected by the AEGIS SGR shall be warranted for the term of the manufacturer's motor warranty from induced bearing current damage.
- F. *Motors up to 100 HP shall be provided with one shaft grounding ring installed on either the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the shaft grounding ring manufacturer's recommendations.*
- G. *All motors operated on variable frequency drives shall be bonded from the motor foot to system ground with a high-frequency ground strap made of flat braided tinned copper with terminations to accommodate motor foot and system ground connection .*

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F .
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 22 0516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Rubber union connector packless expansion joints.
 - 2. Flexible-hose packless expansion joints.
 - 3. Metal-bellows packless expansion joints.
 - 4. Externally pressurized metal-bellows packless expansion joints.
 - 5. Rubber packless expansion joints.
 - 6. Grooved-joint expansion joints.
 - 7. Alignment guides and anchors.
 - 8. Pipe loops and swing connections.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints RUEJ-01:

1. Manufacturers: Subject to compliance with requirements, provide products by the following
 - a. Amber/Booth Company, Inc.; a MC Group Company.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. General Rubber Corporation.
 - e. Mason Industries, Inc.
 - f. Proco Products, Inc.
 - g. Unaflex.
 - h. Unisource Manufacturing, Inc.
2. Material: Twin reinforced-rubber spheres with external restraining cables.
3. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
4. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

B. Flexible-Hose Packless Expansion Joints :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Mason Industries, Inc.
 - d. Metraflex, Inc.
 - e. Unisource Manufacturing, Inc.
2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
4. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 - b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F (2890 kPa at 21 deg C) and 315 psig at 450 deg F (2170 kPa at 232 deg C) ratings.
6. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon-steel fittings with flanged end connections.

- a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
 8. Expansion Joints for Steel Piping NPS 8 to NPS 12 (DN 200 to DN 300): Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F (860 kPa at 21 deg C) and 90 psig at 600 deg F (625 kPa at 315 deg C) ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
 9. Expansion Joints for Steel Piping NPS 14 (DN 350) and Larger: Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F (1130 kPa at 21 deg C) and 120 psig at 600 deg F (830 kPa at 315 deg C) ratings.
- C. Metal-Bellows Packless Expansion Joints :
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adesco Manufacturing LLC.
 - b. American BOA, Inc.
 - c. Badger Industries, Inc.
 - d. Expansion Joint Systems, Inc.
 - e. Flex-Hose Co., Inc.
 - f. Flexicraft Industries.
 - g. Flex-Weld, Inc.
 - h. Hyspan Precision Products, Inc.
 - i. Mason Industries, Inc.
 - j. Metraflex, Inc.
 - k. Tozen Corporation.
 - l. Unaflex.
 - m. Unisource Manufacturing, Inc.
 - n. Universal Metal Hose, a subsidiary of Hyspan Precision Products, Inc.
 - o. U.S. Bellows, Inc.
 - p. WahlcoMetroflex.
 2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 3. Type: Circular, corrugated bellows with external tie rods.
 4. Minimum Pressure Rating: 150 psig (1035 kPa) 175 psig (1200 kPa) Insert value, unless otherwise indicated.
 5. Configuration: Single joint Single joint with base double joint with base class(es), unless otherwise indicated.
 6. Expansion Joints for Copper Tubing: Single- ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint threaded.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint threaded.
 - c. End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
 7. Expansion Joints for Steel Piping: Single- ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.

- b. End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Flanged.
- D. Externally Pressurized Metal-Bellows Packless Expansion Joints:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adscot Manufacturing LLC.
 - b. Hyspan Precision Products, Inc.
 - c. Mason Industries, Inc.
 - d. Metraflex, Inc.
 - e. U.S. Bellows, Inc.
 2. Minimum Pressure Rating: [150 psig (1035 kPa)] [200 psig (1379 kPa)] [300 psig (2068 kPa)] , unless otherwise indicated.
 3. Description:
 - a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
 - b. Carbon-steel housing.
 - c. Drain plugs and lifting lug for NPS 3 (DN 80) and larger.
 - d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.
 - e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
 - f. Joint Axial Movement: [4 inches (100 mm)] [6 inches (150 mm)] [8 inches (200 mm)] of compression and [0.75 inch (19 mm)] [1 inch (25 mm)] [2 inches (50 mm)] of extension.
 4. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
 5. End Connection Configuration: Flanged; one raised, fixed and one floating flange.
- E. Rubber Packless Expansion Joints :
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2.
 - a. Amber/Booth Company, Inc.; a VMC Group Company.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. Flex-Weld, Inc.
 - e. Garlock Sealing Technologies.
 - f. General Rubber Corporation.
 - g. Mason Industries, Inc.
 - h. Metraflex, Inc.
 - i. Proco Products, Inc.
 - j. Red Valve Company, Inc.
 - k. Tozen Corporation.
 - l. Unaflex.
 - m. Unisource Manufacturing, Inc.
 - n. .
 3. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
 4. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
 5. Arch Type: Single multiple arches with external control rods.

6. Spherical Type: Single multiple spheres with external control rods.
7. Minimum Pressure Rating for NPS 1-1/2 to NPS 4 (DN 40 to DN 100): 150 psig (1035 kPa) at 220 deg F (104 deg C) .
8. Minimum Pressure Rating for NPS 5 and NPS 6 (DN 125 and DN 150): 140 psig (966 kPa) at 200 deg F (93 deg C) .
9. Minimum Pressure Rating for NPS 8 to NPS 12 (DN 200 to DN 300): 140 psig (966 kPa) at 180 deg F (82 deg C) .
10. Material for Fluids Containing Acids, Alkalis, or Chemicals: Butyl rubber Chlorosulfonyl-polyethylene rubber Ethylene-propylene-diene terpolymer rubber Insert material.
11. Material for Fluids Containing Gas, Hydrocarbons, or Oil: Buna-N Chlorosulfonated polyethylene synthetic rubber Insert material.
12. Material for Water: Butyl rubber Buna-N Chlorosulfonated polyethylene synthetic rubber Chlorosulfonyl-polyethylene rubber Ethylene-propylene-diene terpolymer rubber Natural rubber.
13. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.3 GROOVED-JOINT EXPANSION JOINTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Anvil International, Inc.
 2. Shurjoint Piping Products.
 3. Victaulic Company.
 4. .
- B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- C. Standard: AWWA C606, for grooved joints.
- D. Nipples: [**Galvanized**,]ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- E. Couplings: [**Five**] [**Seven**] [**10**] [**12**] <Insert number>, flexible type for steel-pipe dimensions. Include ferrous housing sections, [**Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water**] [**ethylene-propylene-diene terpolymer rubber gasket suitable for cold and hot water**], and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides :
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adscos Manufacturing LLC.
 - b. Advanced Thermal Systems, Inc.
 - c. Flex-Hose Co., Inc.
 - d. Flexicraft Industries.
 - e. Flex-Weld, Inc.
 - f. Hyspan Precision Products, Inc.
 - g. Mason Industries, Inc.

- h. Metraflex, Inc.
 - i. Senior Flexonics Pathway.
 - j. Unisource Manufacturing, Inc.
 - k. U.S. Bellows, Inc.
 - l. .
 - 2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- B. Anchor Materials:
- 1. Steel Shapes and Plates: ASTM A 36/A 36M.
 - 2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
 - 3. Washers: ASTM F 844, steel, plain, flat washers.
 - 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
 - 5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- C. Install rubber packless expansion joints according to FSA-PSJ-703.
- D. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least **four** pipe fittings, including tee in riser.

- D. Connect mains and branch connections to terminal units with at least **four** pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install [**one**] [**two**] guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than **four** pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 22 0517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Smith, Jay R. Mfg. Co.
 - 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).
 - 4. Pipeline Seal and Insulator, Inc.
 - 5. Proco Products, Inc.
 - 6. .
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: [**EPDM-rubber**] [**NBR**] interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: [**Plastic**] [**Stainless steel**].
 - 3. Connecting Bolts and Nuts: **Stainless steel** of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Presealed Systems.
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.

- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
 - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 07 9200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150) [Cast-iron wall sleeves] [Galvanized-steel wall sleeves] [Galvanized-steel-pipe sleeves] [Sleeve-seal fittings]
 - 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6 (DN 150) : [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Sleeve-seal fittings] .
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): [Cast-iron wall sleeves with sleeve-seal system] [Galvanized-steel wall sleeves with sleeve-seal system] [Galvanized-steel-pipe sleeves with sleeve-seal system] [Sleeve-seal fittings] .
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): [Galvanized-steel-pipe sleeves] [PVC-pipe sleeves] [Stack-sleeve fittings] [Sleeve-seal fittings] [Molded-PE or -PP sleeves] [Molded-PVC sleeves].
 - 5. Interior Partitions:
 - a. Piping Smaller Than NPS 6 (DN 150): [Galvanized-steel-pipe sleeves] [PVC-pipe sleeves] .

END OF SECTION

SECTION 22 0518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.2 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged, or removed and reinstalled.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following.
 - 1. BrassCraft Manufacturing Co.; a Masco company.
 - 2. Dearborn Brass.
 - 3. ProFlo; a Ferguson Enterprises, Inc. brand.

2.2 ESCUTCHEONS

- A. One-Piece, Stainless-Steel Type: With polished stainless-steel finish.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped steel with polished, chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
- E. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

- A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping and Relocated Existing Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Chrome-Plated Piping: One-piece steel with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece steel with polished, chrome-plated finish or One-piece stainless steel with polished stainless-steel finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish or One-piece stainless steel with polished stainless-steel finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish or One-piece stainless steel with polished stainless-steel finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish or One-piece steel with polished, chrome-plated finish.
 - g. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
 - 2. Escutcheons for Existing Piping to Remain:
 - a. Chrome-Plated Piping: Split-casting, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: Split-plate, stamped steel with concealed or exposed-rivet hinge with polished, chrome-plated finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping and Relocated Existing Piping: One-piece, floor plate.
 - 2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 0519 - METERS AND GAGES FOR PLUMBING PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Liquid-in-glass thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.
 - 4. Gage attachments.
- B. Related Requirements:
 - 1. Section 22 1113 "Facility Water Distribution Piping" for domestic water meters and combined domestic and fire-protection water-service meters outside the building.
 - 2. Section 22 1116 "Domestic Water Piping" for water meters inside the building.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage, from manufacturer.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS**2.1 LIQUID-IN-GLASS THERMOMETERS**

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Trerice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum ; 7-inch (178-mm) nominal size unless otherwise indicated.
 - 4. Case Form: Straight unless otherwise indicated.
 - 5. Tube: Glass with magnifying lens and blue or red organic liquid.
 - 6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.

7. Window: Glass .
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI .
4. Type: Stepped shank unless straight or tapered shank is indicated.
5. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
6. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
7. Bore: Diameter required to match thermometer bulb or stem.
8. Insertion Length: Length required to match thermometer bulb or stem.
9. Lagging Extension: Include on thermowells for insulated piping and tubing.
10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMETEK, Inc.; U.S. Gauge.
 - b. Ashcroft Inc.
 - c. Ernst Flow Industries.
 - d. Flo Fab Inc.
 - e. Marsh Bellofram.
 - f. Miljoco Corporation.
 - g. Noshok.
 - h. Palmer Wahl Instrumentation Group.
 - i. REOTEMP Instrument Corporation.
 - j. Tel-Tru Manufacturing Company.
 - k. Terice, H. O. Co.
 - l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - m. Weiss Instruments, Inc.
 - n. WIKA Instrument Corporation - USA.
 - o. Winters Instruments - U.S.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel ; 6-inch (152-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.

6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass .
10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with [NPS 1/4 (DN 8)] [NPS 1/4 or NPS 1/2 (DN 8 or DN 15)] [NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads and [piston] [porous-metal]-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball Brass or stainless-steel needle, with [NPS 1/4 (DN 8)] [NPS 1/4 or NPS 1/2 (DN 8 or DN 15)] [NPS 1/2 (DN 15)], ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- G. Install valve and snubber in piping for each pressure gage for fluids.
- H. Install thermometers in the following locations:
 1. Inlet and outlet of each water heater.
- I. Install pressure gages in the following locations:
 1. Building water service entrance into building.
 2. Inlet and outlet of each pressure-reducing valve.
 3. Suction and discharge of each domestic water pump.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

- A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
- B. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).
- B. Scale Range for Domestic Hot-Water Piping: 0 to 250 deg F (0 to 150 deg C).

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each water service into building shall be the following:
 - 1. Liquid-filled , direct -mounted, metal case.
 - 2. Test plug with EPDM self-sealing rubber inserts.
- B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:
 - 1. Liquid-filled , -mounted, metal case.
- C. Pressure gages at suction and discharge of each domestic water pump shall be[**one of**] the following:
 - 1. Liquid-filled , direct -mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 200 psi (0 to 1400 kPa).
- B. Scale Range for Domestic Water Piping: 0 to 160 psi (0 to 1100 kPa).

END OF SECTION

SECTION 22 0523.12 - BALL VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Steel ball valves.
3. Iron ball valves.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. RPTFE: Reinforced polytetrafluoroethylene.
- C. WOG: Water, oil, gas.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, and soldered ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 1. Maintain valve end protection.
 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Standards:

1. Domestic water valves intended to convey or dispense water for human consumption must comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or must be certified to be in compliance with NSF 61 and NSF 372 (by an ANSI-accredited third-party certification body) that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.
 - B. ASME Compliance:
 1. ASME B1.20.1 for threads for threaded end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B16.5 for flanges on steel valves.
 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 5. ASME B16.18 for cast copper solder-joint connections.
 6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
 7. ASME B16.34 for flanged and threaded end connections
 8. ASME B31.9 for building services piping valves.
 - C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
 - D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
 - E. Valve Sizes: Same as upstream piping unless otherwise indicated.
 - F. Valve Actuator Type:
 1. Gear Actuator: For quarter-turn valves NPS 4 (DN 100) and larger.
 2. Hand Lever: For quarter-turn valves smaller than NPS 4 (DN 100).
 - G. Valves in Insulated Piping:
 1. Provide 2-inch (50-mm) extended neck stems.
 2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 3. Memory stops that are fully adjustable after insulation is applied.
- 2.3 BRONZE BALL VALVES
- A. Bronze Ball Valves, Two Piece with Full Port and Stainless Steel Trim, Threaded or Soldered Ends:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. WATTS.
 2. Standard: MSS SP-110; MSS SP-145.
 3. CWP Rating: 600 psig (4140 kPa).
 4. Body Design: Two piece.

5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

2.4 STEEL BALL VALVES

- A. Steel Ball Valves with Full Port, Class 150, Flanged or Threaded Ends:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond Valve.
 - c. Jomar Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. WATTS.
 2. Standard: MSS SP-72; MSS SP-110.
 3. CWP Rating: 285 psig (1964 kPa).
 4. Body Design: Split body.
 5. Body Material: Carbon steel, ASTM A216/A216M, Type WCB.
 6. Ends: Flanged or threaded.
 7. Seats: PTFE.
 8. Stem: Stainless steel.
 9. Ball: Stainless steel, vented.
 10. Port: Full.

2.5 IRON BALL VALVES

- A. Iron Ball Valves, Class 125, Flanged or Threaded Ends:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Sure Flow Equipment Inc.
 - d. WATTS.
 2. Standard: MSS SP-72; MSS SP-110; MSS SP-145.
 3. CWP Rating: 200 psig (1380 kPa).
 4. Body Design: Split body.
 5. Body Material: ASTM A126, gray iron.
 6. Ends: Flanged or threaded.
 7. Seats: PTFE.
 8. Stem: Stainless steel.
 9. Ball: Stainless steel.
 10. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.
- B. Provide support to piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position to allow full valve actuation movement.
- F. Valve Tags: Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- G. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
 - 7. For Stainless Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 - 8. For Stainless Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.
 - 9. For Stainless Steel Piping, NPS 2 (DN 50) and Smaller: Press ends.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze ball valves, two piece with full port, and stainless steel trim. Provide with threaded solder-joint ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Steel and Iron Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
 - 2. Steel ball valves, Class 150 with full port.
 - 3. Iron ball valves, Class 150.

END OF SECTION

SECTION 22 0523.14 - CHECK VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Bronze swing check valves.
 - 2. Iron swing check valves.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve.
 - 1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B16.18 for solder joint.
 - 5. ASME B31.9 for building services piping valves.

- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 Annex G and NSF 372.
- E. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

- A. Bronze Swing Check Valves with Bronze Disc, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Apollo Flow Controls; Conbraco Industries, Inc.
 - c. Crane; Crane Energy Flow Solutions.
 - d. Hammond Valve.
 - e. Jenkins Valves; Crane Energy Flow Solutions.
 - f. KITZ Corporation.
 - g. Macomb Groups (The).
 - h. Milwaukee Valve Company.
 - i. NIBCO INC.
 - j. Powell Valves.
 - k. Red White Valve Corp.
 - l. Stockham; Crane Energy Flow Solutions.
 - m. WATTS.
 - n. Insert manufacturer's name.
 - 2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: Bronze.

2.3 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

- A. Iron Swing Check Valves with Lever- and Spring-Closure Control, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Jenkins Valves; Crane Energy Flow Solutions.

- d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Stockham; Crane Energy Flow Solutions.
 - g. WATTS.
 - 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - e. Ends: Flanged or threaded. See valve schedule articles.
 - f. Trim: Bronze.
 - g. Gasket: Asbestos free.
 - h. Closure Control: Factory-installed exterior lever and weight.
- B. Iron Swing Check Valves with Lever and Weight-Closure Control, Class 125:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Jenkins Valves; Crane Energy Flow Solutions.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Stockham; Crane Energy Flow Solutions.
 - g. WATTS.
 - h. .
 - 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - e. Ends: Flanged or threaded. See valve schedule articles.
 - f. Trim: Bronze.
 - g. Gasket: Asbestos free.
 - h. Closure Control: Factory-installed exterior lever and weight.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Check Valves: Install check valves for proper direction of flow.
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
- F. Install valve tags. Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. End Connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded or soldered or press-ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged or threaded.
 - 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze swing check valves with bronze disc, Class 125, with soldered end connections.
 - 2. Bronze swing check valves with press-end connections.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

1. Iron swing check valves with metal seats, Class 125, with threaded or flanged end connections.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Pipe positioning systems.
10. Equipment supports.

B. Related Requirements:

1. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 22 0516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to [ASCE/SEI 7] .
1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 3. Design seismic-restraint hangers and supports for piping and equipment[**and obtain approval from authorities having jurisdiction**].

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

- B. Shop Drawings:[**Signed and sealed by a qualified professional engineer.**] Show fabrication and installation details and include calculations for the following; include Product Data for components:
1. Trapeze pipe hangers.
 2. Metal framing systems.
 3. Fiberglass strut systems.
 4. Pipe stands.
 5. Equipment supports.

1.5 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**].
- B. Stainless-Steel Pipe Hangers and Supports:
1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**stainless steel**].
- C. Copper Pipe Hangers:
1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**copper-coated steel**] [**stainless steel**].

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 FIBERGLASS PIPE HANGERS

- A. Clevis-Type, Fiberglass Pipe Hangers:
1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
 2. Hanger Rods: Continuous-thread rod, washer, and nuts made of [**fiberglass**] [polyurethane] [or] [stainless steel].
- B. Strap-Type, Fiberglass Pipe Hangers:
1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
 2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of [**stainless steel**] .

2.4 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.
 - c. Flex-Strut Inc.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut Corporation; Tyco International, Ltd.
 - g. Wesanco, Inc.
 2. Description: Shop- or field-fabricated pipe support assembly for supporting multiple parallel pipes.
 3. Standard: MFMA-4.
 4. Channels: Continuous slotted steel channel with intumed lips.
 5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [stainless steel] .
 7. Metallic Coating: [**Electroplated zinc**] [Hot-dipped galvanized] [Mill galvanized] [In-line, hot galvanized] [Mechanically-deposited zinc].
 8. Paint Coating: [**Vinyl**] [Vinyl alkyd] [Epoxy] [Polyester] [Acrylic] [Amine] [Alkyd] .
 9. Plastic Coating: [**PVC**] [Polyurethane] [Epoxy] [Polyester] .
 10. Framing systems in paragraph below should be equal to or able to exceed MFMA-4 requirements.
- B. Non-MFMA Manufacturer Metal Framing Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
 - a. Anvil International; a subsidiary of Mueller Water Products Inc.
 - b. Empire Industries, Inc.
 - c. ERICO International Corporation.
 - d. Haydon Corporation; H-Strut Division.
 - e. NIBCO INC.
 - f. PHD Manufacturing, Inc.

- g. PHS Industries, Inc.
- 2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
- 3. Standard: Comply with MFMA-4.
- 4. Channels: Continuous slotted steel channel with intumed lips.
- 5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [stainless steel] .
- 7. Coating: [Zinc] [Paint] [PVC] .

2.5 FIBERGLASS STRUT SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
 - 1. Allied Tube & Conduit.
 - 2. Champion Fiberglass, Inc.
 - 3. Cooper B-Line, Inc.
 - 4. SEASAFE, INC.; a Gibraltar Industries Company.
- B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
 - 1. Channels: Continuous slotted fiberglass[**or other plastic**] channel with intumed lips.
 - 2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**fiberglass**] [stainless steel] .

2.6 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following]:
 - 1. Carpenter & Paterson, Inc.
 - 2. Clement Support Services.
 - 3. ERICO International Corporation.
 - 4. National Pipe Hanger Corporation.
 - 5. PHS Industries, Inc.
 - 6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
 - 7. Piping Technology & Products, Inc.
 - 8. Rilco Manufacturing Co., Inc.
 - 9. Value Engineered Products, Inc.
- B. **Insulation-Insert Material for Cold Piping:** [ASTM C 552, Type II cellular glass with 100-psig (688-kPa)] [or] [ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa)] minimum compressive strength and vapor barrier.
- C. **Insulation-Insert Material for Hot Piping:** [**Water-repellent treated, ASTM C 533, Type I calcium silicate with** 100-psig (688-kPa)] [ASTM C 552, Type II cellular glass with 100-psig (688-kPa)] [or] [ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa)] minimum compressive strength.

- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, [**zinc-coated**] [**stainless-**] steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.8 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece [**plastic**] [**stainless-steel**] base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: [**Plastic**] [**Stainless steel**].
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 PIPE POSITIONING SYSTEMS

- A. Description: IAPMO PS 42, positioning system of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.10 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.11 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
- F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 7200 "Roof Accessories" for curbs.
- I. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- J. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- K. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- L. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- M. Install lateral bracing with pipe hangers and supports to prevent swaying.
- N. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [NPS 2-1/2 (DN 65)] and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- O. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- P. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- Q. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

- a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use and fiberglass pipe hangers fiberglass strut systems and stainless-steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use powder-actuated fasteners mechanical-expansion anchors instead of building attachments where required in concrete construction.
- S. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Valve tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.
 - d. Champion America.
 - e. Craftmark Identification Systems.
 - f. emedco.
 - g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Marking Services Inc.
 - 2. Material and Thickness: stainless steel, 0.025-inch (0.64-mm) and having predrilled or stamped holes for attachment hardware.
 - 3. Letter Color: Black.
 - 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - 5. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 - 6. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

2.2 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Actioncraft Products, Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Identification Systems.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.3 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Actioncraft Products, Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Identification Systems.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
- B. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
 - 1. Tag Material: Brass, 0.032-inch (0.8-mm) , 0.032-inch (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass S-hook.

- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
 - 1. Domestic Water Piping

- a. Background: Safety green.
 - b. Letter Colors: White.
- 2. Sanitary Waste and Storm Drainage Piping:
 - a. Background Color: Safety black .
 - b. Letter Color: White.
- 3. Non-Potable Water Piping
 - a. Background Color: Safety purple
 - b. Letter Color: White
- 4. Natural Gas Piping
 - a. Background Color: Yellow
 - b. Letter Color: Black

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches (38 mm), round.
 - b. Hot Water: 1-1/2 inches (38 mm), round.
 - 2. Valve-Tag Colors:
 - a. Cold Water: Natural.
 - b. Hot Water: Natural.
 - 3. Letter Colors:
 - a. Cold Water: White.
 - b. Hot Water: White.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 22 0719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Supplies and drains for handicap-accessible lavatories and sinks.
- B. Related Requirements:
 - 1. Section 22 0716 "Plumbing Equipment Insulation."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied, if any).
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content and chemical components.
 - 2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that product complies with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- C. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pittsburgh Corning Corporation; Foamglas.
 - 2. Block Insulation: ASTM C 552, Type I.
 - 3. Special-Shaped Insulation: ASTM C 552, Type III.
 - 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 - 5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
 - 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 INSULATING CEMENTS

- A. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 - 1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Ramco Insulation, Inc.; Thermokote V.
 - b. <Insert manufacturer's name; product name or designation>.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Aeroflex USA, Inc.; Aeroseal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.
- C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
 - b. Eagle Bridges - Marathon Industries; 501.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
 - d. Mon-Eco Industries, Inc.; 55-10.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
 5. Color: White.
- D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Eagle Bridges - Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 5. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
- b. Eagle Bridges - Marathon Industries; 550.
- c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
- d. Mon-Eco Industries, Inc.; 55-50.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
 1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
 - c. Vimasco Corporation; 713 and 714.
 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
 5. Color: White.

2.6 SEALANTS

- A. Joint Sealants:
 1. Joint Sealants for Cellular-Glass and Phenolic Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Permanently flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 5. Color: White or gray.
 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
 2. Width: 2 inches (50 mm).
 3. Thickness: 3.7 mils (0.093 mm).
 4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, [provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, [Type 304] [or] [Type 316]; 0.015 inch (0.38 mm) thick, [1/2 inch (13 mm)] [3/4 inch (19 mm)] wide with [wing seal] [or] [closed seal].
 3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [1/2 inch (13 mm)] [3/4 inch (19 mm)] wide with [wing seal] [or] [closed seal].
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: [0.080-inch (2.0-mm) nickel-copper alloy] [0.062-inch (1.6-mm) soft-annealed, stainless steel] [0.062-inch (1.6-mm) soft-annealed, galvanized steel].
1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. C & F Wire.

2.10 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Pipe Covers,
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Engineered Brass Company.
 - b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
 - c. McGuire Manufacturing.
 - d. Plumberex.
 - e. Truebro; a brand of IPS Corporation.
 - f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
 2. Description: Manufactured plastic wraps for covering plumbing fixture [hot-water supply] [hot- and cold-water supplies] and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- B. Protective Shielding Piping Enclosures,
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Truebro; a brand of IPS Corporation.
 - b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
 2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches (50 mm)] [4 inches (100 mm)] o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.
- 3.4 PENETRATIONS
- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- 3.5 GENERAL PIPE INSULATION INSTALLATION
- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.

3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

3.8 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. NPS 1 (DN 25) and Smaller: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inches (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - 2. NPS 1-1/4 (DN 32) and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inches (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
- B. Domestic Hot and Recirculated Hot Water:
 - 1. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
 - 2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 1 inches (25 mm) thick.
 - b. Flexible Elastomeric: 1 inch (25 mm) thick.
- C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch (13 mm) thick.
- D. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet (3 m) of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Flexible Elastomeric: 3/4 inch (19 mm) thick.
- 3.11 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET
 - A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 0800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:
 - 1. Domestic hot- and cold-water piping.
 - 2. Sanitary waste and vent piping.
 - 3. Plumbing pumps.
 - 4. Plumbing equipment.
- B. Related Requirements:
 - 1. Section 01 9113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. Cx: Commissioning, as defined in Section 01 9113 "General Commissioning Requirements."
- B. CxA: Commissioning Authority, as defined in Section 01 9113 "General Commissioning Requirements."
- C. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For plumbing testing technician.
- B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.
- C. Construction Checklists: Material, installation, and performance test checklists for systems, assemblies, subsystems, equipment, and components to be part of the Cx process and according to requirements in Section 01 9113 "General Commissioning Requirements."
 - 1. Facility water distribution piping, including the following:
 - a. Domestic water piping, fittings, and specialties outside the building.
 - b. Pumps, motors, accessories, and controls.
 - c. Sleeves and sleeve seals.
 - d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - 2. Domestic water piping, including the following:
 - a. Domestic cold- and hot-water piping, fittings, and specialties inside the building.
 - b. Pumps, motors, accessories, and controls.
 - c. Sleeves and sleeve seals.

- d. Meters and gages.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
- 3. Sanitary waste and vent piping, including the following:
 - a. Gravity and forced-main sewerage piping, fittings, and specialties.
 - b. Pumps, motors, accessories, and controls.
 - c. Drains.
 - d. Sleeves and sleeve seals.
 - e. Meters and gages.
 - f. General-duty and specialty valves.
 - g. Hangers and supports.
- 4. Plumbing fixtures, including the following:
 - a. Water closets, supports and connections, supplies, and flush valves.
 - b. Lavatories, supports, supplies, drain connections, and faucets.
 - c. Sinks, supports, supplies, drain connections, and faucets.
 - d. Emergency plumbing fixtures, supplies, drain connections, and controls.
- D. Test equipment and instrumentation list, identifying the following:
 - 1. Equipment/instrument identification number.
 - 2. Planned Cx application or use.
 - 3. Manufacturer, make, model, and serial number.
 - 4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 - 5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

- A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of plumbing system, electrical concepts, and building operations.
 - 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. Medical Gas Piping Systems Testing Technician Qualifications: Technicians to perform medical compressed-air, vacuum, and medical gas piping for laboratory and healthcare facilities system construction checklist verification tests, construction checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:

1. Journey level or equivalent skill level. Vocational school four-year-program graduate or an Associate's degree in mechanical systems, plumbing systems, or similar field. Degree may be offset by three years' experience in servicing plumbing systems in the gas piping for laboratory and healthcare facilities plumbing systems industry. Generally, required knowledge includes gas piping for laboratory and healthcare facilities systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of plumbing system equipment, assemblies, and systems.
 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- C. Testing Equipment and Instrumentation Quality and Calibration:
1. Capable of testing and measuring performance within the specified acceptance criteria.
 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- D. Proprietary Test Instrumentation and Tools:
1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Plumbing system proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

- A. Prepare detailed construction checklists for plumbing systems, assemblies, subsystems, equipment, and components.
1. Domestic hot- and cold-water piping.
 2. Sanitary waste and vent piping.
 3. Storm drainage piping.
 4. Plumbing pumps.
 5. Plumbing equipment, including the following:
 - a. Domestic water heating equipment.
 - b. Plumbing fixtures.

3.2 CONSTRUCTION CHECKLIST REVIEW

- A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.

- B. Return draft construction checklist review comments within 10 days of receipt.
- C. When review comments have been resolved, the CxA will provide final construction checklists, marked "Approved for Use, (date)."
- D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 Cx TESTING PREPARATION

- A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved submittals.
- B. Certify that plumbing systems instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 Cx TESTS COMMON TO PLUMBING

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response according to acceptance criteria.

- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with construction checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Division 22 Sections specifying plumbing systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Construction checklist verification tests.
 - 2. Construction checklist verification test demonstrations.
 - 3. Cx tests.
 - 4. Cx test demonstrations.
- F. Supervision of Alarms in Plumbing Systems:
 - 1. Prerequisites: Acceptance of results of construction checklists for plumbing systems specified in the Sections listed below:
 - a. Section 22 1113 "Facility Water Distribution Piping."
 - 2. Scope:
 - a. Monitored plumbing system alarms.
 - 3. Purpose:
 - a. Verify reporting of monitored plumbing alarm at building management system.
 - 4. Conditions of the Test:
 - a. Alarm monitoring systems operating in normal, automatic mode.
 - b. Activate monitored plumbing alarms, one at a time.
 - 5. Acceptance Criteria:
 - a. Activation of monitored plumbing alarm generates alarm at building management system control panel.
- G. Plumbing Meter Reporting:
 - 1. Prerequisites: Acceptance of results of construction checklists for plumbing systems specified in the Sections listed below:
 - a. Section 22 1113 "Facility Water Distribution Piping."
 - b. Section 22 1119 "Domestic Water Piping Specialties."
 - c. Section 22 3100 "Domestic Water Softeners."
 - 2. Scope:
 - a. Monitored plumbing system water meters.
 - 3. Purpose:
 - a. Verify accuracy of reporting of monitored plumbing system water meters at building management system.
 - 4. Conditions of the Test:
 - a. Plumbing system water meter recording systems operating in normal, automatic mode.
 - b. Compare cumulative consumption data at plumbing system water meter recording systems with independent, calibrated flow-measuring instrumentation under the following conditions:
 - 1) Low Flow: 1 percent of maximum design flow rate for a period of four hours.
 - 2) High Flow: 80 percent of maximum design flow rate for a period of 20 minutes.
 - c. Activate monitored plumbing alarms, one at a time.

5. Acceptance Criteria:
 - a. Cumulative flow reported for low-flow condition is within 5 percent flow recorded by calibrated flow-measuring instrumentation.
 - b. Cumulative flow reported for high-flow condition is within 1 percent flow recorded by calibrated flow-measuring instrumentation.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 1113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes water-distribution piping and related components outside the building for water service.
- B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.2 DEFINITIONS

- A. EPDM: Ethylene propylene diene terpolymer rubber.
- B. LLDPE: Linear, low-density polyethylene plastic.
- C. PA: Polyamide (nylon) plastic.
- D. PE: Polyethylene plastic.
- E. PP: Polypropylene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. RTRF: Reinforced thermosetting resin (fiberglass) fittings.
- H. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 1. Wiring Diagrams: Power, signal, and control wiring for alarms.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
 - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 - 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
- E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- G. NSF Compliance:
 - 1. Comply with NSF 14 for plastic potable-water-service piping.
 - 2. Comply with NSF 61 Annex G for materials for water-service piping and specialties for domestic water.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
 - 1. Ensure that valves are dry and internally protected against rust and corrosion.
 - 2. Protect valves against damage to threaded ends and flange faces.
 - 3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
 - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 - 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.
- D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt.
- G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.8 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water-distribution service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of water-distribution service without Owner's written permission.

1.9 COORDINATION

- A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

2.2 JOINING MATERIALS

- A. Refer to Section 33 0500 "Common Work Results for Utilities" for commonly used joining materials.
- B. Brazing Filler Metals: AWS A5.8, BCuP Series.
- C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
- D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Tubular-Sleeve Pipe Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cascade Waterworks Manufacturing Co.
 - b. Dresser, Inc.
 - c. Ford Meter Box Company, Inc.
 - d. Hays Fluid Controls.
 - e. JCM Industries, Inc.
 - f. Smith-Blair, Inc.
 - g. Viking Johnson.
 2. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
 - a. Standard: AWWA C219.
 - b. Center-Sleeve Material: Manufacturer's standard.
 - c. Gasket Material: Natural or synthetic rubber.
 - d. Pressure Rating: 150 psig (1035 kPa) minimum.
 - e. Metal Component Finish: Corrosion-resistant coating or material.
- C. Split-Sleeve Pipe Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company.
 2. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
 - a. Standard: AWWA C219.
 - b. Sleeve Material: Manufacturer's standard.
 - c. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
 - d. Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
 - e. Pressure Rating: 150 psig (1035 kPa) minimum.
 - f. Metal Component Finish: Corrosion-resistant coating or material.
- D. Flexible Connectors:
1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
 2. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.
- E. Dielectric Fittings:
1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
 2. Dielectric Unions:
 - a. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
 3. Dielectric Flanges:
 - a. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.

- 3) Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
- 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- 4. Dielectric-Flange Insulating Kits:
 - a. Description:
 - 1) Nonconducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel backing washers.
- 5. Dielectric Nipples:
 - a. Description:
 - 1) Standard: IAPMO PS 66
 - 2) Electroplated steel nipple. complying with ASTM F 1545.
 - 3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 4) End Connections: Male threaded or grooved.
 - 5) Lining: Inert and noncorrosive, propylene.

2.4 CORROSION-PROTECTION PIPING ENCASEMENT

- A. Encasement for Underground Metal Piping:
 - 1. Standards: ASTM A 674 or AWWA C105.
 - 2. Form: Sheet or tube.
 - 3. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness.
 - 4. Material: LLDPE film of 0.008-inch (0.20-mm) minimum thickness, or high-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.
 - 5. Material: High-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.
 - 6. Color: Black.

2.5 GATE VALVES

- A. Bronze Gate Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Jenkins Valves; Crane Energy Flow Solutions.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Red-White Valve Corporation.
 - g. Stockham; Crane Energy Flow Solutions.
 - 2. OS&Y, Rising-Stem Gate Valves:
 - a. Description: Bronze body and bonnet and bronze stem.
 - 1) Standards: UL 262 and FMG approved.
 - 2) Minimum Pressure Rating: 175 psig (1207 kPa).
 - 3) End Connections: Threaded.
 - 3. Nonrising-Stem Gate Valves:
 - a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
 - 1) Standard: MSS SP-80.

2.6 WATER METERS

- A. Water meters will be furnished by utility company.

2.7 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks.
 - b. Conbraco Industries, Inc.
 - c. FEBCO.
 - d. Flomatic Corporation.
 - e. Watts; a Watts Water Technologies company.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; **[flanged]** **<Insert type>** for NPS 2-1/2 (DN 65) and larger.
6. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate type with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow preventer connection.

B. Backflow Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO.
 - c. Flomatic Corporation.
 - d. Watts; a Watts Water Technologies company.
 - e. Wilkins.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. Underground water-service piping NPS 3 to NPS 8 (DN 100 to DN 200) shall be the following:
 - 1. Ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings; and gasketed joints.

3.3 VALVE APPLICATIONS

- A. General Application: Use mechanical-joint-end valves for NPS 3 (DN 80) and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 (DN 50) and smaller installation.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. See Section 33 0500 "Common Work Results for Utilities" for piping-system common requirements.

3.5 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Make connections larger than NPS 2 (DN 50) with tapping machine according to the following:
 - 1. Install tapping sleeve and tapping valve according to MSS SP-60.
 - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.
 - 4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
- D. Make connections NPS 2 (DN 50) and smaller with drilling machine according to the following:
 - 1. Install service-saddle assemblies and corporation valves in size, quantity, and arrangement required by utility company standards.
 - 2. Install service-saddle assemblies on water-service pipe to be tapped. Position outlets for corporation valves.
 - 3. Use drilling machine compatible with service-saddle assemblies and corporation valves. Drill hole in main. Remove drilling machine and connect water-service piping.
 - 4. Install corporation valves into service-saddle assemblies.
 - 5. Install manifold for multiple taps in water main.
 - 6. Install curb valve in water-service piping with head pointing up and with service box.
- E. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.

- F. Bury piping with depth of cover over top at least , with top at least 12 inches (300 mm) below level of maximum frost penetration, and according to the following:
 - 1. In Loose Gravelly Soil and Rock: With at least 12 inches (300 mm) additional cover.
- G. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- H. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
 - 1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
- I. Sleeves are specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- J. Mechanical sleeve seals are specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- K. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
- L. See Section 22 1116 "Domestic Water Piping" for potable-water piping inside the building.

3.6 JOINT CONSTRUCTION

- A. See Section 33 0500 "Common Work Results for Utilities" for basic piping joint construction.
- B. Make pipe joints according to the following:
 - 1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
 - 2. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - a. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples unions.
 - b. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges flange kits nipples.
 - c. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.7 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
 - 1. Concrete thrust blocks.
 - 2. Locking mechanical joints.
 - 3. Set-screw mechanical retainer glands.
 - 4. Bolted flanged joints.
 - 5. Heat-fused joints.
 - 6. Pipe clamps and tie rods.
 - 7.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:

1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.
3. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.
4. Fire-Service-Main Piping: According to NFPA 24.

- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
- D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.
- E. MSS Valves: Install as component of connected piping system.
- F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
- G. Relief Valves: Comply with AWWA C512. Install aboveground with shutoff valve on inlet.

3.9 WATER METER INSTALLATION

- A. Install water meters, piping, and specialties according to utility company's written instructions.

3.10 BACKFLOW PREVENTER INSTALLATION

- A. Install backflow preventers of type, size, and capacity indicated. Include valves and test cocks. Install according to requirements of plumbing and health department and authorities having jurisdiction.
- B. Do not install backflow preventers that have relief drain in vault or in other spaces subject to flooding.
- C. Do not install bypass piping around backflow preventers.
- D. Support NPS 2-1/2 (DN 65) and larger backflow preventers, valves, and piping near floor and on brick or concrete piers.

3.11 PROTECTIVE ENCLOSURE INSTALLATION

- A. Install concrete base level and with top approximately 2 inches (50 mm) above grade.
- B. Install protective enclosure over valves and equipment.
- C. Anchor protective enclosure to concrete base.

3.12 CONNECTIONS

- A. See Section 33 0500 "Common Work Results for Utilities" for piping connections to valves and equipment.
- B. Connect water-distribution piping to interior domestic water and fire-suppression piping.

3.13 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
 - 1. Increase pressure in 50-psig (350-kPa) increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig (0 kPa). Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts (1.89 L) per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- C. Prepare reports of testing activities.

3.14 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 31 2000 "Earth Moving."
- B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 33 0500 "Common Work Results for Utilities" for identifying devices.

3.15 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
 - 3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.

- c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 1116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
 - 2. Encasement for piping.
- B. Related Requirements:
 - 1. Section 22 1113 "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.2 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.

1.4 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
 - 2. Do not interrupt water service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
- B. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- D. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

- E. Copper Unions:
1. MSS SP-123.
 2. Cast-copper-alloy, hexagonal-stock body.
 3. Ball-and-socket, metal-to-metal seating surfaces.
 4. Solder-joint or threaded ends.
- F. Copper Pressure-Seal-Joint Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following
 - a. Elkhart Products Corporation.
 - b. NIBCO Inc.
 - c. Viega LLC.
 2. Fittings for NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
 3. Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end.
- G. Copper-Tube, Extruded-Tee Connections:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. T-Drill Industries Inc.
 2. Description: Tee formed in copper tube according to ASTM F 2014.
- H. Appurtenances for Grooved-End Copper Tubing:
1. Manufacturers: Subject to compliance with requirements, provide products by the following
 - a. Anvil International; a subsidiary of Mueller Water Products, Inc.
 - b. Shurjoint Piping Products
 - c. Victaulic Company.
 2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
 3. Mechanical Couplings for Grooved-End Copper Tubing:
 - a. Copper-tube dimensions and design similar to AWWA C606.
 - b. Ferrous housing sections.
 - c. EPDM-rubber gaskets suitable for hot and cold water.
 - d. Bolts and nuts.
 - e. Minimum Pressure Rating: 300 psig (2070 kPa).

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:
1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.

- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- F. Solvent Cements for Joining CPVC Piping and Tubing: ASTM F 493.
- G. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- H. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 ENCASEMENT FOR PIPING

- A. Standard: ASTM A 674 or AWWA C105/A21.5.
- B. Form: Sheet or tube.
- C. Color: Black or natural.

2.5 TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Coupling: AWWA C219.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Cascade Waterworks Manufacturing Co.
 - b. Dresser, Inc.
 - c. Ford Meter Box Company, Inc. (The).
 - d. JCM Industries, Inc.
 - e. Romac Industries, Inc.
 - f. Smith-Blair, Inc.
 - g. Viking Johnson.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.

- c. Central Plastics Company.
 - d. Hart Industries International, Inc.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. Watts; a Watts Water Technologies company.
 - h. Wilkins.
 - 2. Standard: ASSE 1079.
 - 3. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - 4. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
- 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca.
 - d. Watts; a Watts Water Technologies company.
 - e. Wilkins.
 - 2. Standard: ASSE 1079.
 - 3. Factory-fabricated, bolted, companion-flange assembly.
 - 4. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - 5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric Nipples:
- 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Elster Perfection Corporation.
 - b. Grinnell Mechanical Products.
 - c. Matco-Norca.
 - d. Precision Plumbing Products, Inc.
 - e. Victaulic Company.
 - 2. Standard: IAPMO PS 66.
 - 3. Electroplated steel nipple complying with ASTM F 1545.
 - 4. Pressure Rating and Temperature: [300 psig (2070 kPa) at 225 deg F (107 deg C)]
 - 5. End Connections: Male threaded or grooved.
 - 6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install underground copper tube ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 22 0519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 22 1119 "Domestic Water Piping Specialties."
- F. Install shutoff valve immediately upstream of each dielectric fitting.
- G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 1119 "Domestic Water Piping Specialties."
- H. Install domestic water piping level and plumb.
- I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- L. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- N. Install piping to permit valve servicing.
- O. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- P. Install piping free of sags and bends.
- Q. Install fittings for changes in direction and branch connections.
- R. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

- S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 22 0519 "Meters and Gages for Plumbing Piping."
- T. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 1123 "Domestic Water Pumps."
- U. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 0519 "Meters and Gages for Plumbing Piping."
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 0518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
- G. Push-on Joints for Copper Tubing: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.
- H. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

- I. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
- J. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.
- K. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- L. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings unions.

3.5 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings or nipples nipples unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges flange kits nipples.
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger, support products, and installation in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:

- a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 4. Base of Vertical Piping: MSS Type 52, spring hangers.
 - C. Support vertical piping and tubing at base and at each floor.
 - D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
 - E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
 - F. Install supports for vertical copper tubing every 10 feet (3 m).
 - G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
 5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
 6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
 7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
 8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.
 - H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.
- 3.7 CONNECTIONS
- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
 - C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
 - D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
 2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.

- C. Prepare test and inspection reports.

3.10 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.
 - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 - 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 - 7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
 - 3. Secondary disinfection is required for projects constructed in phases before building is turned over to the owner, to prevent Legionella and other pathogens growth in standing domestic water system.
- B. Clean non-potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.

- D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Under-building-slab, domestic water, building-service piping, NPS 3 (DN 80) and smaller, shall be the following:
 - 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A) ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and brazed copper pressure-seal fittings; and pressure-sealed joints.
- E. Under-building-slab, domestic water piping, NPS 2 (DN 50) and smaller, shall be one of the following:
 - 1. Hard or soft copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.
- F. Aboveground domestic water piping, NPS 2 (DN 50) and smaller, shall be the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.
- G. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and soldered joints.

3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - 2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated Memory-stop balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

FOR REFERENCE ONLY

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backflow preventers.
2. Balancing valves.
3. Temperature-actuated, water mixing valves.
4. Strainers.
5. Hose bibbs.
6. Wall hydrants.
7. Ground hydrants.
8. Water-hammer arresters.
9. Trap-seal primer valves.
10. Trap-seal primer systems.
11. Flexible connectors.
12. Water meters.

B. Related Requirements:

1. Section 22 0519 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 22 1116 "Domestic Water Piping" for water meters.
3. Section 22 3200 "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Section 22 4300 "Medical Plumbing Fixtures" for thermostatic mixing valves for sitz baths, thermostatic mixing-valve assemblies for hydrotherapy equipment, and outlet boxes for dialysis equipment.
5. Section 22 4500 "Emergency Plumbing Fixtures" for water tempering equipment.
6. Section 22 4713 "Drinking Fountains" for water filters for water coolers.
7. Section 22 4716 "Pressure Water Coolers" for water filters for water coolers.
8. Section 22 4723 "Remote Water Coolers" for water filters for water coolers.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For domestic water piping specialties.

1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig (860 kPa) unless otherwise indicated.

2.3 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Ames Fire & Waterworks.
 - b. Conbraco Industries, Inc.
 - c. FEBCO.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.4 BALANCING VALVES

- A. Copper-Alloy Calibrated Balancing Valves :

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Armstrong International, Inc.
 - b. Tour & Andersson (Victaulic)
 - c. Flo Fab Inc.
 - d. ITT Corporation.
 - e. NIBCO Inc.
 - f. Schneider Electric USA, Inc.
 - g. TACO Incorporated.
 - h. Watts; a Watts Water Technologies company.
2. Type: **[Ball] [or] [Y-pattern globe]** valve with two readout ports and memory-setting indicator.

3. Body: **[Brass]** [or] **[bronze]**.
4. Size: Same as connected piping, but not larger than NPS 2 (DN 50).
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
6. etting indicator.
7. Size: Same as connected piping, but not smaller than NPS 2-1/2 (DN 65).

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

C. Memory-Stop Balancing Valves :

1. Manufacturers: Subject to compliance with requirements, provide products by the following
 - a. Conbraco Industries, Inc.
 - b. Tour & Andersson (Victaulic)
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO Inc.
 - f. Red-White Valve Corporation.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
4. Size: NPS 2 (DN 50) or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.5 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices :

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Armstrong International, Inc.
 - b. Cash Acme.
 - c. Conbraco Industries, Inc.
 - d. Honeywell Water Controls.
 - e. Legend Valve.
 - f. Leonard Valve Company.
 - g. Powers; a division of Watts Water Technologies, Inc.
 - h. Symmons Industries, Inc.
 - i. TACO Incorporated.
 - j. Watts; a Watts Water Technologies company.
 - k. Zurn Industries, LLC.
 - l. Tour & Andersson (Victaulic)
2. Standard: ASSE 1070.
3. Pressure Rating: 125 psig (860 kPa).
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

8. Valve Finish: Rough bronze.

B. Primary, Thermostatic, Water Mixing Valves :

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Armstrong International, Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.
 - d. Powers; a division of Watts Water Technologies, Inc.
 - e. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Type: thermostatically controlled, water mixing valve.
5. Connections: Threaded union inlets and outlet.
6. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.

2.6 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig (860 kPa).
7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Include operating key with each operating-key hose bibb.
13. Include[**integral**] wall flange with each chrome- or nickel-plated hose bibb.

2.7 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Josam Company.
 - a. MIFAB, Inc.
 - b. Prier Products, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; a subsidiary of McWane, Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - g. Zurn Industries, LLC.
3. Standard: ASME A112.21.3M for concealed -outlet, self-draining wall hydrants.
4. Pressure Rating: 125 psig (860 kPa).
5. Operation: Loose key.

6. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
7. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
8. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
9. Box: Deep, flush mounted with cover.
10. Box and Cover Finish: Polished nickel bronze.
11. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
12. Nozzle and Wall-Plate Finish: Polished nickel bronze.
13. Operating Keys(s): One with each wall hydrant.

2.8 GROUND HYDRANTS

A. Nonfreeze Ground Hydrants :

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
2. acturer's name; product name or designation> or comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Murdock-Super Secur; a member of Morris Group International.
 - d. Prier Products, Inc.
 - e. Smith, Jay R. Mfg. Co.
 - f. Tyler Pipe; a subsidiary of McWane, Inc.
 - g. Watts; a Watts Water Technologies company.
 - h. Woodford Manufacturing Company.
 - i. Zurn Industries, LLC.
3. Standard: ASME A112.21.3M.
4. Type: Nonfreeze, concealed-outlet ground hydrant with box.
5. Operation: Loose key.
6. Casing and Operating Rod: Of at least length required for burial of valve below frost line.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: Garden-hose thread complying with ASME B1.20.7.
9. Drain: Designed with hole to drain into ground when shut off.
10. Box: **[Standard] [Deep]** pattern with cover.
11. Box and Cover Finish: Polished nickel bronze.
12. Operating Key(s): One with each ground hydrant.
13. Vacuum Breaker: ASSE 1011.

2.9 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters :

1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Precision Plumbing Products, Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Smith, Jay R. Mfg. Co.

- g. Tyler Pipe; a subsidiary of McWane, Inc.
- h. Watts; a Watts Water Technologies company.
- i. Zurn Industries, LLC.
- 2. Standard: ASSE 1010 or PDI-WH 201.
- 3. Type: **[Metal bellows] [Copper tube with piston]**.
- 4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.10 TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device :

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. MIFAB, Inc.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.
 - e. Watts; a Watts Water Technologies company.
- 2. Standard: ASSE 1018.
- 3. Pressure Rating: 125 psig (860 kPa) minimum.
- 4. Body: Bronze.
- 5. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.
- 6. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.
- 7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

B. Drainage-Type, Trap-Seal Primer Device :

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Smith, Jay R. Mfg. Co.
- 2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 (DN 10) minimum, trap makeup connection.
- 3. Size: NPS 1-1/4 (DN 32) minimum.
- 4. Material: Chrome-plated, cast brass.

2.11 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following :
 - a. Precision Plumbing Products, Inc.
- 2. Standard: ASSE 1044.
- 3. Piping: NPS 3/4, ASTM B 88, Type L (DN 20, ASTM B 88M, Type B); copper, water tubing.
- 4. Cabinet: **[Recessed] [Surface]**-mounted steel box with stainless-steel cover.
- 5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
 - a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 6. Vacuum Breaker: ASSE 1001.
- 7. Number Outlets: **[Four] [Six] [Eight] <Insert number>**.
- 8. Size Outlets: [NPS 1/2 (DN 15)] [NPS 5/8 (DN 18)].

2.12 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following :
1. Flex-Hose Co., Inc.
 2. Flexicraft Industries.
 3. Flex Pression Ltd.
 4. Flex-Weld Incorporated.
 5. Hyspan Precision Products, Inc.
 6. Mercer Gasket & Shim, Inc.
 7. Metraflex Company (The).
 8. Proco Products, Inc.
 9. TOZEN Corporation.
 10. Unaflex.Universal Metal Hose.
- B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
1. Working-Pressure Rating: Minimum [200 psig (1380 kPa)] [250 psig (1725 kPa)].
 2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
- C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
1. Working-Pressure Rating: Minimum [200 psig (1380 kPa)] [250 psig (1725 kPa)].
 2. End Connections NPS 2 (DN 50) and Smaller: Threaded steel-pipe nipple.
 3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.13 WATER METERS

- A. Displacement-Type Water Meters:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. AALIAN
 - b. ABB.
 - c. Carlon Meter.
 - d. Mueller Co.
 - e. Schlumberger Limited.
 - f. Sensus.
 - g. Badger Meter
 2. Description:
 - a. Standard: AWWA C700.
 - b. Pressure Rating: 150-psig (1035-kPa) working pressure.
 - c. Body Design: Nutating disc; totalization meter.
 - d. Registration: In gallons (liters) or cubic feet (cubic meters) as required by utility company.
 - e. Case: Bronze.
 - f. End Connections: Threaded.

- B. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.
- C. Remote Registration System: Encoder type complying with AWWA C707; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- B. Install balancing valves in locations where they can easily be adjusted.
- C. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- D. Install Y-pattern strainers for water on supply side of each water pressure-reducing valve.
- E. Install ground hydrants with [1 cu. yd. (0.75 cu. m)] **<Insert dimension>** of crushed gravel around drain hole. Set ground hydrants with box flush with grade.
- F. Set nonfreeze, nondraining-type post hydrants in concrete or pavement.
- G. Install water-hammer arresters in water piping according to PDI-WH 201.
- H. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- I. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

- A. Comply with requirements for ground equipment in Section 26 0526 "Grounding and Bonding for Electrical Systems."

- B. Fire-retardant-treated-wood blocking is specified in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Pressure vacuum breakers.
 - 2. Reduced-pressure-principle backflow preventers.
 - 3. Calibrated balancing valves.
 - 4. Primary, thermostatic, water mixing valves.
 - 5. Supply-type, trap-seal primer valves.
 - 6. Trap-seal primer systems.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test each reduced-pressure-principle backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Hose bibbs.
- B. Mistert
- C. Pool Bubblers
- D. Pool Overflow Stand Pipe

1.2 REFERENCE STANDARDS

- A. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers; 2023.
- B. NSF 61 - Drinking Water System Components - Health Effects; 2025, with Addendum
- C. NSF 372 - Drinking Water System Components - Lead Content; 2024.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's literature and data sheets for each product. Include information on materials of fabrication, assembly of components, dimensions, ratings, finishes, rough-in requirements, and installed accessories.
- C. Maintenance Materials: Furnish the following for Owner's use in project maintenance:
 - 1. See Section 01 6000 - Product Requirements for additional provisions.
 - 2. Extra Loose Keys for Hose Bibbs: Two.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. See Section 01 7419 - Construction Waste Management and Disposal for packaging waste requirements.
- B. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.
- C. Keep products in original manufacturer's packaging and protect from damage until ready for installation.
- D. Store products under cover and protected from weather and dirt. Elevate above grade.
- E. Protect end connections, flanges, threads, and grooves from dirt and damage.
- F. Protect product interiors against rust and corrosion.
- G. Do not use operating handles or stems as lifting or rigging points.

1.5 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Specialties in Potable Water Supply Systems: Provide products complying with NSF 61 and NSF 372.
- B. Source Limitations: Furnish domestic water piping specialties of same kind by same manufacturer.
- C. Provide brass-bodied domestic water piping specialties in DZR brass.

2.2 HOSE BIBBS

- A. Manufacturers:

1. Zurn.
 2. Woodford
 3. Jay R Smith
 4. Prier
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Hose Bibbs:
1. Valve: Bronze or brass body with mounting flange, replaceable seat, hose thread spout, and integral or add-on vacuum breaker complying with ASSE 1011.
 2. Operation:
 - a) Exposed Locations in Finished Areas: Loose key.
 3. Finishes:
 - a) Exposed Locations in Finished Areas: Provide in polished chrome or polished brass.
 4. Maximum Working Pressure: 125 psi (8.6 bar).
 5. Working Temperature Range: 33 to 120 degrees F (0.5 to 50 degrees C).

PART 3 EXECUTION

3.1 EXAMINATION

- A. Discard packing materials and verify product interiors are free from debris, damage, and corrosion.
- B. Verify end connections, flanges, threads, and grooves are completely clean without signs of damage or degradation that could result in leakage.
- C. For products containing isolation or shutoff valves, verify isolation and shutoff valves operate smoothly from fully closed to fully open.

3.2 INSTALLATION

- A. Prior to installation of domestic water piping specialties, flush domestic water piping of foreign material.
- B. Install products in accordance with manufacturer's instructions.
- C. Install products level and plumb.
- D. Install products with clearance for access and maintenance.
- E. Support products NPS 2-1/2 (DN 65) and larger independently of surrounding pipe.
- F. Support products with flanged or grooved ends independently of surrounding pipe.
- G. For products containing isolation or shutoff valves, locate valves in horizontal piping with stems at or above center of piping, maintaining unimpeded stem movement.
- H. Locate as indicated on the drawings

3.3 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements for additional requirements.
- B. Inspect each product for damage and defects.
- C. Repair or replace damaged products.
- D. Replace defective products.
- E. For products containing isolation or shutoff valves, exercise isolation and shutoff valves from fully closed to fully open. Confirm smooth operation.
- F. Coordination of Other Tests and Inspections: Provide access to accommodate tests and inspections by independent testing agencies employed by Owner.

3.4 CLEANING

- A. See Section 01 7000 - Execution and Closeout Requirements for additional requirements.
- B. Clean products to remove dirt, paint, and other foreign materials.
- C. Clean surfaces of products exposed to view in finished spaces to remove dirt, fingerprints, paint, and other foreign materials. Restore finishes to match original factory finish.
- D. Clean surfaces of products exposed to view on building exterior to remove dirt, fingerprints, paint, and other foreign materials. Restore finishes to match original factory finish.
- E. Clean strainers, including those internal to other products, prior to mm-dd-yyyy.

3.5 PROTECTION

- A. Protect installed products from damage due to subsequent construction operations.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 1123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. In-line, sealless centrifugal pumps.

1.2 DEFINITIONS

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water pumps to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following]:
 - 1. Armstrong Pumps Inc.

2. Bell & Gossett; a Xylem brand.
 3. Grundfos Pumps Corp.
 4. TACO Incorporated.
- B. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
- C. Pump Construction:
1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
 2. Casing: Bronze, with threaded or companion-flange connections.
 3. Impeller: Plastic.
 4. Motor: Single speed, unless otherwise indicated.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 CONTROLS

- A. Pressure Switches: Electric, adjustable for control of water-supply pump.
1. Type: Water-immersion pressure sensor, for installation in piping.
 2. Operation of Pump: On or off.
 3. Transformer: Provide if required.
- B. Thermostats: Electric; adjustable for control of hot-water circulation pump.
1. Type: Water-immersion temperature sensor, for installation in piping.
 2. Range: 65 to 200 deg F (18 to 93 deg C) .
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.
- C. Install horizontally mounted, in-line, close-coupled centrifugal pumps with shaft(s) horizontal.

- D. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
- E. Install continuous-thread hanger rods and spring hangers of size required to support pump weight.
 - 1. Comply with requirements for vibration isolation devices specified in Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.
 - 2. Comply with requirements for hangers and supports specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- F. Install pressure switches in water supply piping.
- G. Install thermostats in hot-water return piping.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 1116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 22 1116 "Domestic Water Piping."
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for valves specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.13 "Butterfly Valves for Plumbing Piping," Section 22 0523.14 "Check Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping," and comply with requirements for strainers specified in Section 22 1119 "Domestic Water Piping Specialties."
 - 1. Install pressure gage at suction of each pump and pressure gage at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Section 22 0519 "Meters and Gages for Plumbing Piping."
- E. Connect pressure switches, thermostats, to pumps that they control.

3.4 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set pressure switches, thermostats, for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 7. Start motor.
 - 8. Open discharge valve slowly.
 - 9. Adjust temperature settings on thermostats.
 - 10. Adjust timer settings.

3.6 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION

SECTION 22 1313 – FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Sanitary sewer piping.
 - 2. Manholes.
 - 3. Flexible couplings.
 - 4. Flexible pipe boots for manhole pipe entrances
- B. Related Requirements:
 - 1. Section 312000 – Earth Moving

1.2 REFERENCES

- A. ASTM International (ASTM):
 - 1. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
 - 2. ASTM D3034 – Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
 - 3. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
 - 4. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
 - 5. ASTM F679 – Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
 - 6. ASTM F794 – Standard Specification for Poly(Vinyl Chloride) (PVC) Profiled Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
 - 7. ASTM F1336 – Standard Specification for Poly(Vinyl Chloride) (PVC) Gasketed Sewer Fittings.
 - 8. ASTM F1417 – Standard Practice for Installation Acceptance of Plastic Non-Pressure Sewer Lines Using Low-Pressure Air.
- B. DC Water:
 - 1. DC Water Standard Specifications.

1.3 SUBMITTALS

- A. Product Data:
 - 1. Sanitary sewer piping.
 - 2. Manholes.
 - 3. Flexible couplings.
 - 4. Flexible pipe boots for manhole pipe entrances.
- B. Information:
 - 1. Source Quality-Control Reports: For piping and accessories.
 - 2. Field Quality-Control Reports: For piping and accessories.
 - 3. Qualifications Statements: For manufacturer and installer.
 - 4. Manufacturer's certification and test result reports.
 - 5. Field inspection data for deflection, visual, and leakage acceptance tests.

- C. Closeout:

1. Submit layout drawings showing:
 - a. Direction of lay.
 - b. Starting and finish points.
 - c. Lay lengths.
 - d. Bending, bending radius and offsets, and deflection angles.
 - e. Locations and lengths of cut segments of pipe.
 - f. Fittings and fitting locations.
 - g. Manholes and other appurtenances.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage:

1. Upon receipt of each product, inspect for damage and conformance to the Contract Documents.
2. Verify manufacturer's certification accompanies pipe at delivery.
3. Store products in accordance with the manufacturer's recommendations.
4. Prevent exposure to sources of heat or hot objects such as heaters, boilers, steam lines, and engine exhaust.
5. Protect gaskets from exposure to heat, direct sunlight, ozone, oil and grease, dust and grit, and solvents.
6. Do not store gaskets close to electrical equipment that produces ozone.

B. Handling:

1. Handle and store products in accordance with the manufacturer's recommendations and the following requirements:
 - a. Handle pipe carefully and prevent severe impact blows, abrasion damage, gouging, and cutting of pipe.
 - b. Never handle pipe with individual chain or single cable, even if padded.

- C. Remove defective or damaged products from the Project Site and replace with acceptable products, at Contractor's expense.

1.5 QUALITY ASSURANCE

- A. Submit manufacturer's certifications and reports showing test results per ASTM D3034 and ASTM F679.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. Unless shown otherwise on Drawings, PVC Pipe and Fittings shall be as follows:

1. ASTM D3034.
2. Standard Dimension Ratio (SDR) rating: Minimum 35.
3. Joining System: Elastomeric Gasket Joints.
4. Gaskets: ASTM F477 elastomeric, factory assembled and secured.
5. Fittings: ASTM F1336.
6. Saddle wye-branches are not permitted.

2.2 PIPE BEDDING

- A. Crushed Stone or Screened Gravel Size No. 57 per Section 31 20 00 – Earth Moving.

2.3 MANHOLES

- A. Doghouse Manhole: Per DC Water Standard Detail S20.12
- B. Manhole: Per DC Water Standard Detail S-20.01
- C. Frame and Cover: DC Water Detail S-80.02
- D. Refer to Section 33 42 00 Stormwater Conveyance for additional specifications.

PART 3 - EXECUTION

3.1 GENERAL

- A. Perform trench excavation and backfill in accordance with Section 31 20 00 Earth Moving.

3.2 MAINTAINING SEWER SERVICE

- A. Maintain existing sewer service at all times by conducting operations in a manner that maintains flows or uses bypass pumping in existing sewers.
- B. Perform bypass pumping in accordance with DC Water Standard Specification Section 33 29 60 Sewer Bypass Pumping.

3.3 BACKFILL AND COMPACTION FOR PIPING

- A. Install Embedment Zone materials in accordance with Section 31 20 00 Earth Moving, except as noted below:
 - 1. Bedding Zone for Embedment Zone shall be Crushed Stone wrapped in Geotextile Fabric.
 - 2. Provide a minimum depth of cover 36-inches or one (1) pipe diameter, whichever is larger, before allowing vehicles or construction equipment to traffic the trench surface.
- B. Prior to installing pipe, verify bedding accurately reflects final slope of pipe with uniform bearing for the pipe which will prevent sags, high points, and pressure points in the pipe alignment.

3.4 INSTALLATION FOR PIPING

- A. General:
 - 1. Comply with manufacturer's recommendations for pipe installation, joint components, lubrication, and making joints.
 - 2. Secure pipe against movement and seal open ends to prevent the entrance of water, mud, or foreign material when pipe laying is interrupted.
- B. Laying and alignment:
 - 1. Lay pipe from the lowest invert elevation to the highest invert elevation with the bells facing upstream.
 - 2. Place pipe and fittings on bedding with the invert conforming to the required elevations, slopes, and alignment.
 - 3. Provide bell holes in pipe bedding, no larger than necessary to ensure uniform pipe support.
 - 4. Fill all voids under the bell by working in bedding material.
 - 5. When Drawings show pipe to be installed to a curved alignment, obtain curvature as follows:

- a. For SDR 35 pipe, use longitudinal bending as follows:
 - 1) 6-inch Diameter
 - a) 150-foot minimum radius.
 - b) 20-foot length equivalent linear offset: 16-inches.
 - c) 14-foot length equivalent linear offset: 7.8-inches.
 - 2) 8-inch Diameter
 - a) 200-foot minimum radius.
 - b) 20-foot length equivalent linear offset: 12-inches.
 - c) 14-foot length equivalent linear offset: 5.9-inches.
- b. Utilize manufacturer's recommendation for the minimum radius or the radius listed above, whichever is greater.

C. Jointing:

1. Mark or verify that pipe ends are marked with insertion stop position.
2. Clean all joint surfaces immediately before joining.
3. Lubricate joint with a lubricant approved by the manufacturer.
4. Align the spigot to the bell and insert the spigot into the bell, keeping true to the line and grade, until it contacts the gasket uniformly. Do not swing spigot into bell.
5. Push spigot into bell using methods recommended by the manufacturer, keeping pipe true to line and grade.
6. Protect the end of the pipe while inserting the spigot into the bell and do not use excessive force that may result in over-assembled joints or dislodged gaskets.
7. If undue resistance to insertion of the end is encountered or the insertion depth is not properly reached, disassemble the joint, verify the position and condition of the gasket, repair or replace damaged items, clean joint, and reassemble as defined above.
8. Adjust curvature, not to exceed limits listed above, to maintain alignment shown on Drawings.

D. Field Cut Pipe:

1. Use field cut pipe only when approved by Engineer.
2. Mark pipe around entire circumference.
3. Cut pipe on mark ensuring a square cut.
4. Bevel the end with a beveling tool, wood rasp, or power sander to the same angle and length as provided on the factory-finished pipe.
5. Round off any sharp edges on the leading edge of the bevel.
6. Redraw the insertion line on the spigot using a factory-marked spigot as guide.
7. Install and pipe as defined above.

3.5 ACCEPTANCE TESTING FOR PIPING

- A. Perform the acceptance testing listed in Specification in the presence of Engineer.

B. Visual Inspection and Grade Tolerance:

1. Visually inspect pipe in accordance with DC Water Specification 33 01 28 Inspection of Sewers for Cleaning, Repairs, Lining, and New Pipe Installations, to verify accuracy of alignment, joint construction, and freedom from debris and obstructions. Visual inspection and grade tolerance is considered acceptable if:
 - a. After flowing water through the pipe and terminating water flow, the pipe shows no visible signs of puddling, or
 - b. The total variation from the flow line (plus or minus) over the length of the pipe segment (14 or 20 foot) does not exceed:
 - 1) 6-inch to 12-inch pipe: $\frac{3}{4}$ -inch.

C. Leakage Testing:

1. Perform low-pressure air testing in accordance with ASTM F1417. Leakage test is considered acceptable if the pressure drop in the pipe:
 - a. Is less than 1.0-psig for the duration designated in Table 1 of ASTM F1414, or
 - b. Has no recordable leakage (zero psig drop) after 1-hour of testing.
2. At Engineer's discretion, pipe with a size and length requiring the minimum time of test for a 1.0-psig pressure drop to be tested for a duration that exceeds two (2) hours may be tested and accepted based on a 0.5-psig pressure drop in accordance with Table 2 of ASTM F1417.
3. At Engineer's discretion, when groundwater is below the pipe invert, a hydrostatic test may be performed on short lengths of pipe and building sewer connections as follows:
 - a. Plug the pipe at points of connection and fill with water to provide a minimum of ten (10) feet of head.
 - b. Hold the water in the system for at least 15 minutes before beginning the leakage test.
 - c. Allowable leakage rate of 0.0316-gallon per hour per ten feet of building sewer connection pipe for a test duration of not less than two (2) hours.

D. Deflection Testing:

1. Engineer reserves the right to require deflection testing to be performed and will notify the Contractor within 30 days of completing installation and other acceptance testing if it is to be performed.
 - a. Perform deflection testing not less than 30 days following completion of installation and other acceptance testing using a mandrel, sized in accordance with ASTM D3034 and F679.
 - b. Pipe with an integral diameter of the barrel that is not reduced by more than 7.5 percent of its base diameter is acceptable.

3.6 MANHOLES

- A. Follow the requirements noted in Section 33 42 00 Stormwater Conveyance.

END OF SECTION

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hubless, cast-iron soil pipe and fittings.
 - 2. Epoxy coated cast iron soil pipe and fittings.
 - 3. Stainless steel drainage pipe and fittings.
 - 4. Copper tube and fittings.
 - 5. Specialty pipe fittings.
 - 6. Encasement for underground metal piping.
- B. Related Requirements:
 - 1. Section 22 1329 "Sanitary Sewerage Pumps" for effluent and sewage pumps.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and elevations, or Building Information Model (BIM) drawn to scale, showing items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
- C. Field quality control reports.

1.4 WARRANTY

- A. Listed manufacturers to provide labeling and warranty of their respective products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation are capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10 ft. head of water (30 kPa head of water).
 - 2. Waste, Force-Main Piping: 50 psig (345 kPa).

2.2 PIPING MATERIALS

- A. Piping materials to bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AB & I Foundry; a part of the McWane family of companies.
 - 2. Charlotte Pipe and Foundry Company.
 - 3. Tyler Pipe; a part of McWane family of companies.
- B. Pipe and Fittings:
 - 1. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
 - a. Plainly marked with date of manufacture (pipe only).
 - b. Country of origins.
 - c. Name of manufacturer or manufacturer's registered trademark by which the manufacturer can be readily identified after installation.
 - 2. ASTM A888 or CISPI 301.
 - 3. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
 - 4. Listed by NSF International.
- C. CISPI, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Charlotte Pipe and Foundry Company.
 - c. Fernco Inc.
 - d. Mission Rubber Company, LLC; a division of MCP Industries.
 - e. Tyler Pipe; a subsidiary of McWane Inc.
 - 2. Standards: ASTM C1277 and CISPI 310.
 - 3. Description: Stainless steel corrugated shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
- D. Heavy-Duty, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Charlotte Pipe and Foundry Company.
 - c. Mission Rubber Company, LLC; a division of MCP Industries.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - 2. Standards: ASTM C1277 and ASTM C1540.
 - 3. Description: Stainless steel shield with stainless steel bands and tightening devices; and ASTM C564, rubber sleeve with integral, center pipe stop.
 - 4.

2.4 EPOXY COATED, HUB AND SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AB & I Foundry; a part of the McWane family of companies.
 2. Charlotte Pipe and Foundry Company.
 3. Tyler Pipe; a subsidiary of McWane Inc.
- B. Pipe and Fittings:
1. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
 - a. Plainly marked with date of manufacture (pipe only).
 - b. Country of origins.
 - c. Name of manufacturer or manufacturer's registered trademark by which the manufacturer can be readily identified after installation.
 2. ASTM A888 or CISPI 301 and ASTM A74.
 3. Listed by NSF International.
 4. The pipe coating shall consist of chemically deposited zinc-phosphate pretreatment layer followed by an electrically deposited, high performance cathodic epoxy coating, and finally an electrically deposited, high performance anodic epoxy top coat. The fitting coating shall consist of a chemically deposited zinc-phosphate pretreatment layer followed by an electrically deposited, high performance cathodic epoxy coating, and finally an epoxy acrylic powder top coat.
- C. Pipe and Fittings:
1. Marked with CISPI collective trademark.
 2. ASTM A74, service and extra-heavy cast iron.
- D. Gaskets: ASTM C564, rubber.CISPI,

2.5 COPPER TUBE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 2. Cambridge-Lee Industries, LLC.
 3. Cerro Flow Products, LLC.
 4. Wieland Copper Products, LLC.
- B. Copper Type DWV Tube: ASTM B306, drainage tube, drawn temper.
- C. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- D. Hard Copper Tube: ASTM B88, Type K (ASTM B88M, Type A), water tube, drawn temper.
- E. Copper Pressure Fittings:
1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- G. Solder: ASTM B32, lead free with ASTM B813, water-flushable flux.

2.6 SPECIALTY PIPE FITTINGS

A. Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections of same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Shielded, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company, LLC; a division of MCP Industries.
 - b. Standard: ASTM C1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. End Connections: Same size as and compatible with pipes to be joined.
4. Pressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - 2) Cascade Waterworks Mfg. Co.
 - 3) EBAA Iron Sales, Inc.
 - 4) Ford Meter Box Company, Inc. (The).
 - 5) JCM Industries, Inc.
 - b. Standard: AWWA C219.
 - c. Description: Metal sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - d. Center-Sleeve Material: Manufacturer's standard Carbon steel Ductile iron Malleable iron.
 - e. Gasket Material: Natural or synthetic rubber.
 - f. Metal Component Finish: Corrosion-resistant coating or material.

B. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) A.Y. McDonald Mfg. Co.
- 2) GF Piping Systems: Georg Fischer LLC.
- 3) Jomar Valve.
- 4) Matco-Norca.
- 5) WATTS; A Watts Water Technologies Company.
- 6) Wilkins.
- 7) Zurn Industries, LLC.
- b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 150 psig (1035 kPa).
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
3. Dielectric Nipples:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 - 2) Elster Perfection; Honeywell.
 - 3) Matco-Norca.
 - 4) Precision Plumbing Products.
 - 5) Victaulic Company.
 - b. Description:
 - 1) Standard: IAPMO PS 66.
 - 2) Electroplated steel nipple.
 - 3) Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - 4) End Connections: Male threaded or grooved.
 - 5) Lining: Inert and noncorrosive, propylene.
- 2.7 ENCASEMENT FOR UNDERGROUND METAL PIPING
 - A. Standard: ASTM A674 or AWWA C105/A 21.5.
 - B. Material: Linear low-density polyethylene film of 0.008-inch (0.20-mm) or high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm)] minimum thickness.
 - C. Form: Sheet or tube.
 - D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.

2. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
 1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
 2. Use long-turn, double Y-branch, and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
 - a. Straight tees, elbows, and crosses may be used on vent lines.
 3. Do not change direction of flow more than 90 degrees.
 4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of waste piping in direction of flow is prohibited.
- K. Lay buried building waste piping beginning at low point of each system.
 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 3. Maintain swab in piping and pull past each joint as completed.
- L. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
 1. Building Sanitary Waste: Two percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; Two percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 2. Horizontal Sanitary Waste Piping: Two percent downward in direction of flow.
 3. Vent Piping: One percent down toward vertical fixture vent or toward vent stack.
- M. Install cast-iron soil piping in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping in accordance with ASTM A674 or AWWA C105/A 21.5.
 - N. Install steel piping in accordance with applicable plumbing code.
 - O. Install aboveground copper tubing in accordance with CDA's "Copper Tube Handbook."
 - P. Install aboveground PVC piping in accordance with ASTM D2665.
 - Q. Install engineered soil and waste and vent piping systems as follows:
 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 - R. Install underground, copper, force-main tubing in accordance with CDA's "Copper Tube Handbook."
 1. Install encasement on piping in accordance with ASTM A674 or AWWA C105/A 21.5.
 - S. Install force mains at elevations indicated.
 - T. Plumbing Specialties:
 1. Install backwater valves in sanitary waster gravity-flow piping.
 - a. Comply with requirements for backwater valves specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
 - a. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping.
 - b. Comply with requirements for cleanouts specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 3. Install drains in sanitary waste gravity-flow piping.
 - a. Comply with requirements for drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 - U. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - V. Install sleeves for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for sleeves specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
 - W. Install sleeve seals for piping penetrations of concrete walls and slabs.
 1. Comply with requirements for sleeve seals specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
 - X. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for escutcheons specified in Section 22 0518 "Escutcheons for Plumbing Piping."
- 3.3 JOINT CONSTRUCTION
- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

- B. Hub-and-Spigot, Cast-Iron Soil Piping Caulked Joints: Join in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum caulked joints.
- C. Hubless, Cast-Iron Soil Piping Coupled Joints:
 - 1. Join hubless, cast-iron soil piping in accordance with CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.
 - 1. Cut threads full and clean using sharp dies.
 - 2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - c. Do not use pipe sections that have cracked or open welds.
- E. Join copper tube and fittings with soldered joints in accordance with ASTM B828. Use ASTM B813, water-flushable, lead-free flux and ASTM B32, lead-free-alloy solder.
- F. Grooved Joints: Cut groove ends of pipe in accordance with AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- G. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
- H. Joint Restraints and Sway Bracing:
 - 1. Provide joint restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
 - a. Provide axial restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
 - b. Provide rigid sway bracing for pipe and fittings 4 inches (100 mm) and larger, upstream and downstream of all changes in direction 45 degrees and greater.
 - c. Provide rigid sway bracing for pipe and fittings 5 inches (125 mm) and larger, upstream and downstream of all changes in direction and branch openings.

3.4 INSTALLATION OF SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in ODs.
 - 2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
 - 3. In Aboveground Force Main Piping: Fitting-type transition couplings.
 - 4. In Underground Force Main Piping:
 - a. NPS 1-1/2 (DN 40) and Smaller: Fitting-type transition couplings.
 - b. NPS 2 (DN 50) and Larger: Pressure transition couplings.
- B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric nipples.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
4. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF VALVES

- A. General valve installation requirements for general-duty valve installation are specified in the following Sections:
 1. Section 22 0523.12 "Ball Valves for Plumbing Piping."
 2. Section 22 0523.14 "Check Valves for Plumbing Piping."
- B. Shutoff Valves:
 1. Install shutoff valve on each sewage pump discharge.
 2. Install full-port ball valve for piping NPS 2 (DN 50) and smaller.
 3. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated on plans.
 2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
 3. Install backwater valves in accessible locations.
 4. Comply with requirements for backwater valve specified in Section 22 1319 "Sanitary Waste Piping Specialties."

3.6 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 0511, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 0511, COMMON WORK RESULTS FOR PLUMBING the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply
- C. Install hangers for cast-iron, steel, stainless steel, and copper soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for ABS and PVC piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.

- F. Support vertical runs of cast-iron, steel, stainless steel, and copper soil piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- G. Support vertical runs of ABS and PVC piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect waste and vent piping to the following:
 - 1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Install horizontal backwater valves with cleanout cover flush with floor or in pit with pit cover flush with floor.
 - 6. Comply with requirements for backwater valves, cleanouts and drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 - 7. Equipment: Connect waste piping as indicated.
 - a. Provide shutoff valve if indicated and union for each connection.
 - b. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.
- D. Connect force-main piping to the following:
 - 1. Sanitary Sewer: To exterior force main.
 - 2. Sewage Pump: To sewage pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- F. Make connections in accordance with the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.

- B. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary waste and vent piping in accordance with procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
 - a. Close openings in piping system and fill with water to point of overflow, but not less than 10 ft. head of water (30 kPa head of water).
 - b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
 - c. Inspect joints for leaks.
 - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
 - a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1 inch wg (250 Pa).
 - b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
 - c. Air pressure must remain constant without introducing additional air throughout period of inspection.
 - d. Inspect plumbing fixture connections for gas and water leaks.
 - 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 6. Prepare reports for tests and required corrective action.
- E. Test force-main piping in accordance with procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials.
 - a. Isolate test source and allow to stand for four hours.
 - b. Leaks and loss in test pressure constitute defects that must be repaired.
3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. Repair damage to adjacent materials caused by waste and vent piping installation.

3.11 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller are to be the following:
 1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
 2. Stainless steel pipe and fittings, sealing rings, and gasketed joints.
 3. Copper Type DWV tube, copper drainage fittings, and soldered joints.
 4. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- C. Aboveground, vent piping NPS 4 (DN 100) is to be the following:
 1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints.
 2. Epoxy coated cast iron soil pipe and fittings
 3. Stainless steel pipe and fittings gaskets, and gasketed joints.
 4. Copper Type DWV tube, copper drainage fittings, and soldered joints.
 5. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- D. Underground, soil, waste, and vent piping NPS 4 (DN 100) and smaller are to be the following:
 1. Epoxy coated cast iron soil pipe and fittings
 2. Stainless steel pipe and fittings, gaskets, and gasketed joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- E. Soil, waste, and vent piping branch piping from trench drains (aboveground and underground) to be the following:
 1. Epoxy coated cast iron soil pipe and fittings
 2. Stainless steel pipe and fittings, gaskets, and gasketed joints.
 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- F. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 (DN 65 to DN 150) are to be the following:

1. Hard copper tube, Type K; copper pressure fittings; and soldered joints.
- G. Underground sanitary-sewage force mains NPS 4 (DN 100) and smaller are to be the following:
 1. Hard copper tube, Type K; wrought-copper pressure fittings; and soldered joints.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cleanouts.
 - 2. Miscellaneous sanitary drainage piping specialties.
- B. Related Requirements:
 - 1. Section 07 6200 "Sheet Metal Flashing and Trim" for metal roof flashing assemblies.
 - 2. Section 07 7200 "Roof Accessories" for preformed flashings.
 - 3. Section 07 8413 "Penetration Firestopping" for through-penetration firestop assemblies.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile butadiene styrene.
- B. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show fabrication and installation details for frost-resistant vent terminals.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

- A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary waste piping specialty components.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. WATTS.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hub-and-spigot, cast-iron soil pipe T-branch Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk Countersunk or raised-head Raised-head, brass cast-iron plastic plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Stainless Steel Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BLÜCHER; A Watts brand.
 - b. Josam Company.
2. Standard: ASME A112.3.1.
3. Size: Same as connected drainage piping.
4. Body Material: Stainless steel tee with side cleanout as required to match connected piping.
5. Closure: Stainless steel plug with seal.

C. Cast-Iron Exposed Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. WATTS.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M for adjustable housing cast-iron soil pipe with cast-iron ferrule heavy-duty, adjustable housing threaded, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing Cast-iron soil pipe with cast-iron ferrule Heavy-duty, adjustable housing Threaded, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required Required.
7. Outlet Connection: Inside calk Spigot Threaded.

8. Closure: Brass plug with straight threads and gasket Brass plug with tapered threads
Cast-iron plug Plastic plug.
 9. Adjustable Housing Material: Cast iron Plastic Insert material with threads setscrews or other device.
 10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy Painted cast iron
Polished bronze Rough bronze Stainless steel Insert material and finish.
 11. Frame and Cover Shape: Round Square Insert shape.
 12. Top-Loading Classification: Extra Heavy Heavy Light Medium Duty.
 13. Riser: ASTM A74, Extra-Heavy Service Class, cast-iron drainage pipe fitting and riser to cleanout.
- D. Stainless Steel Exposed Floor Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BLÜCHER; A Watts brand.
 - b. Josam Company.
 - c. Kusel Equipment Co.
 - d. Zurn Industries, LLC.
 2. Standards: ASME A112.3.1[; NSF listed].
 3. Size: Same as connected branch.
 4. Housing: Type 304 stainless steel Type 316 stainless steel.
 5. Closure: Stainless steel with seal Plastic plug.
 6. Riser: ASTM A74, Extra-Heavy Service Class, stainless steel cast-iron drainage pipe fitting and riser to cleanout.
 7. Body or Ferrule: Stainless steel.
 8. Clamping Device: Not required Required.
 9. Outlet Connection: Inside caulk Spigot Threaded Butt-weld.
 10. Adjustable Housing Material: Cast iron Plastic Insert material with threads setscrews or other device.
 11. Frame and Cover Material and Finish: Stainless steel.
 12. Frame and Cover Shape: Round Square Insert shape.
 13. Top-Loading Classification: Extra Heavy Heavy Light Medium Duty.
- E. Cast-Iron Wall Cleanouts:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. WATTS.
 - e. Zurn Industries, LLC.
 2. Standard: ASME A112.36.2M. Include wall access.
 3. Size: Same as connected drainage piping.
 4. Body: Hub-and-spigot, cast-iron soil pipe T-branch Hubless, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure Plug:
 - a. Brass Cast iron.
 - b. Countersunk or raised head.
 - c. Drilled and threaded for cover attachment screw.

- d. Size: Same as or not more than one size smaller than cleanout size.
- 6. Wall Access, Cover Plate: Round, deep, chrome-plated bronze flat, chrome-plated brass or stainless steel cover plate with screw.

2.3 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

- 1. Description: Shop or field fabricate from ASTM A74, Service Class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C564 rubber gaskets.
- 2. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:

- 1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
- 2. Size: Same as connected waste piping.
 - a. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.
 - b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

C. Floor-Drain, Trap-Seal Primer Fittings:

- 1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
- 2. Size: Same as floor drain outlet with NPS 1/2 (DN 15) side inlet.

D. Air-Gap Fittings:

- 1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
- 2. Body: Bronze or cast iron.
- 3. Inlet: Opening in top of body.
- 4. Outlet: Larger than inlet.
- 5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device:

- 1. Description: Manufactured, cast-iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 1 inch (25 mm) 2 inches (51 mm) Insert dimension above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
- 2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings:

- 1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
- 2. Size: Same as connected stack vent or vent stack.

- G. Vent Caps:
 - 1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
 - 2. Size: Same as connected stack vent or vent stack.
- H. Frost-Resistant Vent Terminals:
 - 1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
 - 2. Design: To provide 1-inch (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.
- I. Expansion Joints:
 - 1. Standard: ASME A112.6.4.
 - 2. Body: Cast iron with bronze sleeve, packing, and gland.
 - 3. End Connections: Matching connected piping.
 - 4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- E. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- F. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- G. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- H. Install vent caps on each vent pipe passing through roof.

- I. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.
- J. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- K. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.
- L. Install wood-blocking reinforcement for wall-mounting-type specialties.
- M. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 PIPING CONNECTIONS

- A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment, to allow service and maintenance.

3.3 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
 - 1. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 1319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Floor drains.
 - 2. Floor sinks.
 - 3. Trench drains.

1.2 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

- A. Cast-Iron Floor Drains:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Commercial Enameling Company.
 - b. Jay R. Smith Mfg. Co.
 - c. Josam Company.
 - d. MIFAB, Inc.
 - e. Prier Products, Inc.
 - f. Sioux Chief Manufacturing Company, Inc.
 - g. Wade; a subsidiary of McWane Inc.
 - h. WATTS.
 - i. Zurn Industries, LLC.

2. Standard: ASME A112.6.3.
3. Pattern: Area Floor drain.
4. Seepage Flange: Required.
5. Anchor Flange: Required.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Top Loading Classification: Extra Heavy Duty Heavy Duty Light Duty Medium Duty
Delete if not applicable.
9. Trap Pattern: Deep-seal P-trap.

2.3 FLOOR SINKS

A. Stainless-Steel Floor Sinks, ASME A112.6.7:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Wade; a subsidiary of McWane Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
2. Standard: ASME A112.6.7.
3. Pattern: Floor drain.
4. Body Material: Stainless steel.
5. Anchor Flange: Not required.
6. Clamping Device: Not required.
7. Outlet: Bottom, no-hub connection.
8. Sediment Bucket: .
9. Internal Strainer: Dome.
10. Internal Strainer Material: Stainless steel.
11. Top Grate Material: Stainless steel.
12. Top of Body and Grate Finish: Stainless steel.
13. Top Shape: Square.
14. Top Loading Classification: No traffic.
15. Funnel: Not required. .

2.4 TRENCH DRAINS

A. Trench Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. Wade; a subsidiary of McWane Inc.
 - f. WATTS/Blucher
 - g. Zurn Industries, LLC.
2. Standard: ASME A112.6.3 for trench drains.
3. Material: Stainless Steel

4. Outlet: Bottom.
5. Grate Material: IFRP.
6. Trap Material: Stainless steel.
7. Trap Pattern: Standard P-trap.
 - a. Blucher

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
 - b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
 - c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
 4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- B. Install trench drains at low points of surface areas to be drained.
 1. Set grates of drains flush with finished surface, unless otherwise indicated.
- C. Comply with ASME A112.3.1 for installation of stainless-steel channel drainage systems.
 1. Install on support devices, so that top will be flush with adjacent surface.
- D. Install FRP channel drainage system components on support devices, so that top will be flush with adjacent surface.
- E. Install plastic channel drainage system components on support devices, so that top will be flush with adjacent surface.

3.2 CONNECTIONS

- A. Comply with requirements in Section 22 1316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 22 1319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.
- C. Comply with requirements in Section 22 1323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- D. Install piping adjacent to equipment to allow service and maintenance.

- E. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 1329 - SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Submersible sewage pumps.
 - 2. Sewage-pump basins and basin covers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SEWAGE PUMPS

- A. Submersible, Quick-Disconnect, Cutter Sewage Pumps:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
 - a. ABS Pumps Inc.
 - b. Alyan Pump Company.

- c. Barnes; Crane Pumps & Systems.
 - d. BJM Pumps, LLC.
 - e. EBARA Fluid Handling.
 - f. HOMA Pump Technology Inc.
 - g. Liberty Pumps.
 - h. Metropolitan Pump Industries.
 - i. Pentair Pump Group; Hydromatic Pumps.
 - j. Stancor, Inc.
 - k. Tsurumi America, Inc.
 - l. Vaughan Co., Inc.
 - m. Weil Pump Company, Inc.
 - n. WILO-EMU USA LLC.
 - o. Zoeller Company.
2. Description: Factory-assembled and -tested, grinder sewage-pump unit with guide-rail supports.
 3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.
 4. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail supports.
 5. Impeller: Bronze or stainless steel; statically and dynamically balanced, with stainless-steel cutter, or slicer assembly; capable of handling solids; and keyed and secured to shaft.
 6. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings.
 7. Seal: Mechanical.
 8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - a. Motor Housing Fluid: Air.
 9. Controls:
 - a. Enclosure: NEMA 250, Type 4X; wall-mounted.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 10. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
 11. Guide-Rail Supports:
 - a. Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."
 - b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
 - c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.

- d. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
- e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
- f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
- g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

2.2 SEWAGE-PUMP BASINS AND BASIN COVERS

- A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
 - 1. Material: Fiberglass.
 - 2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports if used, and accessories.
 - 3. Anchor Flange: Steel, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
 - 4. Sewage-pump basin covers typically are round with openings for multiplex pumps.
- B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - 1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation and filling are specified in Section 31 2000 "Earth Moving."

3.2 EXAMINATION

- A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.3 INSTALLATION

- A. Pump Installation Standards:
 - 1. Comply with HI 1.4 for installation of centrifugal pumps.
 - 2. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.

- B. Wiring Method: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 1316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Pumps and controls will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Insert startup steps if any.

3.7 ADJUSTING

- A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 1413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe, tube, and fittings.
 - 2. Specialty pipe fittings.
 - 3. Encasement for underground metal piping.
- B. Related Requirements:
 - 1. Section 33 4100 "Storm Utility Drainage Piping" for storm drainage piping outside the building.

1.2 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water (30 kPa).

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.5 PROJECT CONDITIONS

- A. Interruption of Existing Storm-Drainage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of storm-drainage service.
 - 2. Do not proceed with interruption of storm-drainage service without Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service Extra Heavy classes.
- B. Gaskets: ASTM C 564, rubber.

2.3 ENCASEMENT FOR UNDERGROUND METAL PIPING

- A. Standard: ASTM A 674 or AWWA C105.
- B. Material: High-density, crosslaminated PE film of 0.004-inch (0.10-mm) LLDPE film of 0.008-inch (0.20-mm) minimum thickness.
- C. Form: Sheet.
- D. Color: Black.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
 - L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow.
 - M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
 - N. Install steel piping according to applicable plumbing code.
 - O. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 22 1423 "Storm Drainage Piping Specialties."
 - 2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 22 1423 "Storm Drainage Piping Specialties."
 - P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 22 0517 "Sleeves and Sleeve Seals for Plumbing Piping."
 - R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 22 0518 "Escutcheons for Plumbing Piping."
- 3.3 JOINT CONSTRUCTION
- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
 - B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

3.4 VALVE INSTALLATION

- A. General valve installation requirements are specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.14 "Check Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping."
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - 1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
 - 2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
- C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
 - 2. Install backwater valves in accessible locations.
 - 3. Comply with requirements for backwater valves specified in Section 22 1423 "Storm Drainage Piping Specialties."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel Insert material pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel fiberglass pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel Insert material pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

- F. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
 2. Install horizontal backwater valves with cleanout cover flush with floor in pit with pit cover flush with floor. Insert description.
 3. Comply with requirements for backwater valves cleanouts specified in Section 22 1423 "Storm Drainage Piping Specialties."
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

- A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.9 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Underground storm drainage piping NPS 6 (DN 150) and smaller shall be the following:
 - 1. Extra Heavy Service class, cast-iron soil pipe and fittings; gaskets; and gasketed calking materials; and calked joints.

END OF SECTION

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

FOR REFERENCE ONLY

SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Miscellaneous storm drainage piping specialties.
 - 2. Cleanouts.
 - 3. Trench drains.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.3 QUALITY ASSURANCE

- A. Provide drainage piping specialties are to bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

Standard: ASME A112.6.4.

2.1 CLEANOUTS

- A. Cast-Iron Cleanouts:
 - 1. Cast-Iron Exposed Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2) Watts Water Technologies; a Watts company.
 - 3) Zurn Industries, LLC.
 - b. Standard: ASME A112.36.2M.
 - c. Size: Same as connected branch.
 - d. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
 - e. Closure: Countersunk or raised-head, brass or cast-iron plug.
 - f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.
 - 2. Cast-Iron Exposed Floor Cleanouts:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2) Watts Water Technologies; a Watts company.
 - 3) Zurn Industries, LLC.
 - b. Standard: ASME A112.36.2M.
 - c. Size: Same as connected branch.
 - d. Type: Heavy-duty, adjustable housing unless otherwise noted in the plumbing drawing fixture schedule.
 - e. Body or Ferrule: Cast iron.

- f. Outlet Connection: No-hub unless otherwise noted in the plumbing drawing fixture schedule.
 - g. Closure: Brass plug with straight threads and gasket unless otherwise noted in the plumbing drawing fixture schedule.
 - h. Adjustable Housing Material: Cast iron with threads, setscrews or other device unless otherwise noted in the plumbing drawing fixture schedule.
 - i. Frame and Cover Material and Finish: Nickel-bronze, copper alloy unless otherwise noted in the plumbing drawing fixture schedule.
 - j. Frame and Cover Shape: Round.
 - k. Top Loading Classification: Extra-Heavy Duty unless otherwise noted in the plumbing drawing fixture schedule.
 - l. Riser: ASTM A74, Extra-Heavy Class, cast-iron drainage pipe fitting and riser to cleanout unless otherwise noted in the plumbing drawing fixture schedule.
 - m. Options:
 - 1) Clamping device.
3. Cast-Iron Test Tees:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2) Watts Water Technologies; a Watts company.
 - 3) Zurn Industries, LLC.
 - b. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
 - c. Size: Same as connected drainage piping.
 - d. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
 - e. Closure Plug: Countersunk or raised head, brass.
 - f. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

2.2 TRENCH DRAINS

- A. Trench Drains:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Zurn Industries, LLC.
 - 2. Standard: ASME A112.6.3.
 - 3. Body Material: Cast iron unless otherwise noted in the plumbing drawing fixture schedule.
 - 4. Dimensions of Frame and Grate: See plumbing drawing fixture schedule.
 - 5. Top-Loading Classification: Extra-Heavy Duty unless otherwise noted in the plumbing drawing fixture schedule.
 - 6. Grate Material: Ductile iron or stainless steel unless otherwise noted in the plumbing drawing fixture schedule.
 - 7. Grate Finish: See plumbing drawing fixture schedule.
 - 8. Flange: Anchor, Seepage unless otherwise noted in the plumbing drawing fixture schedule.
 - 9. Outlet: Bottom unless otherwise noted in the plumbing drawing fixture schedule.
 - 10. Outlet Type: Inside caulk unless otherwise noted in the plumbing drawing fixture schedule.
 - 11. Options:
 - a. Clamping device.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains in accordance with roof membrane manufacturer's written installation instructions at low points of roof areas.
 - 1. Install flashing collar or flange of roof drain to maintain integrity of waterproof membranes where penetrated.
 - 2. Install expansion joints, if indicated, in roof drain outlets.
 - 3. Position roof drains for easy access and maintenance.
 - 4. Provide roof drain extension as required to get roof drain to final height required for roofing.
- B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
- C. Install downspout boots at grade with top 12 inches (305 mm) above grade. Secure to building wall.
- D. Install downspout nozzles at exposed bottom of conductors where they spill onto grade.
- E. Install cleanouts in aboveground piping and building drain piping in accordance with the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at minimum intervals of 50 ft. (15 m) for piping NPS 4 (DN 100) and smaller and 100 ft. (30 m) for larger piping.
 - 4. Locate cleanouts at base of each vertical storm piping conductor.
- F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- H. Install horizontal backwater valves in floor with cover flush with floor.
- I. Install drain-outlet backwater valves in outlet of drains.
- J. Install test tees in vertical conductors and near floor.
- K. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- L. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- M. Assemble channel drainage system components in accordance with manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.

- N. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.
 - 1. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 1414 "Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 INSTALLATION OF FLASHING

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.4 CLEANING

- A. Clean piping specialties during installation and remove dirt and debris as work progresses.

3.5 PROTECTION

- A. Protect piping specialties during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic and construction work.
- B. Place plugs in ends of uncompleted piping at end of each day and when work stops.

END OF SECTION

SECTION 22 3400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of commercial, gas-fired, gas-fired, tankless, residential, gas-fired, commercial, oil-fired, residential, oil-fired, and commercial, gas- and oil-fired, domestic-water heater, from manufacturer.
- B. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.
- C. ASME Compliance:
 - 1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Where ASME-code construction is indicated, fabricate and label commercial, finned-tube, domestic-water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.

- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects."

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Two year(s).
 - b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

- A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Lochinvar, LLC.
 - b. PVI Industries, LLC.
 - c. Rheem Manufacturing Company.
 - d. Smith, A. O. Corporation.
 - 2. Standard: ANSI Z21.10.3/CSA 4.3.
 - 3. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
 - 4. Storage-Tank Construction: ASME-code steel with [150-psig (1035-kPa)] minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 5. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.

- c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
- d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
- e. Jacket: Steel with enameled finish.
- f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
- g. Temperature Control: Adjustable thermostat.
- h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
- i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
- 6. Draft Hood: Draft diverter, complying with ANSI Z21.12.
 - a. .
- 7. Electrical Characteristics:
 - a. Volts: 120.
 - b. Phase: Single.
 - c. Hertz: 60.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. AMTROL Inc.
 - b. Flexcon Industries.
 - c. Honeywell Water Controls.
 - d. Pentair Pump Group.
 - e. Smith, A. O. Corporation.
 - f. State Industries.
 - g. Taco, Inc.
- 2. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system operating pressure at tank.
- 3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 Annex G barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

- D. Heat-Trap Fittings: ASHRAE 90.2.
- E. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.13 "Butterfly Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping."
 - 1. Comply with requirements for balancing valves specified in Section 22 1119 "Domestic Water Piping Specialties."
- F. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.
- G. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 2-psig (13.8-kPa) pressure rating as required to match gas supply.
- H. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.
- I. Combination Temperature-and-Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
 - 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.
- J. Pressure Relief Valves: Include pressure setting less than domestic-water heater working-pressure rating.
 - 1. Gas-Fired, Domestic-Water Heaters: ANSI Z21.22/CSA 4.4-M.
- K. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4-M.
- L. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Provide dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.
- M. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect assembled domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 4000 "Quality Requirements" for retesting and reinspecting requirements and Section 01 7300 "Execution" for requirements for correcting the Work.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in [Section 03 3000 "Cast-in-Place Concrete."] [Section 03 3053 "Miscellaneous Cast-in-Place Concrete."]
1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 2. Maintain manufacturer's recommended clearances.
 3. Arrange units so controls and devices that require servicing are accessible.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 8. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 0523.12 "Ball Valves for Plumbing Piping," Section 22 0523.13 "Butterfly Valves for Plumbing Piping," and Section 22 0523.15 "Gate Valves for Plumbing Piping."
- C. Install gas-fired, domestic-water heaters according to NFPA 54.
1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
 4. Comply with requirements for gas shutoff valves, gas pressure regulators, and automatic gas valves specified in Section 23 1123 "Facility Natural-Gas Piping."
- D. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- E. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

- F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 22 1119 "Domestic Water Piping Specialties."
- G. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 22 0519 "Meters and Gages for Plumbing Piping."
- H. Fill domestic-water heaters with water.
- I. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Section 22 1116 "Domestic Water Piping."
- B. Comply with requirements for gas piping specified in Section 23 1123 "Facility Natural-Gas Piping."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 4000 "Quality Requirements" for retesting and reinspecting requirements and Section 01 7300 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters.

END OF SECTION

FOR REFERENCE ONLY

SECTION 22 4213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wall-mounted water closets.
 - 2. Flushometer valves.
 - 3. Toilet seats.
 - 4. Supports.

1.2 DEFINITIONS

Retain terms that remain after this Section has been edited for a project. Include only essential definitions or acronyms not well understood by the affected industry or trade..

- A. High-Efficiency Flush Volume: 1.1 gal. (4.8 L) or less per flush.
- B. WaterSense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the WaterSense performance criteria.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power and control wiring.
- C. Sustainable Design Submittals:
 - 1. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves and electronic sensors to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Materials: Furnish extra materials to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to 10percent of amount of each type installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Comply with ASME A112.19.2/CSA B45.1 for water closets.
2. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets and tanks.
3. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.
4. Comply with IAMPO/ANSI Z124.5 for water-closet (toilet) seats.
5. Comply with ASME A112.6.1M for water-closet supports.
6. Comply with ICC A117.1 for ADA-compliant water closets.
7. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous china water closets to sanitary drainage systems.
8. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous china water closets to sanitary drainage systems.

2.2 WALL-MOUNTED WATER CLOSETS

A. Water Closets - Wall Mounted, Top Spud:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. Sloan Valve Company.
 - d. TOTO USA, INC.
 - e. Zurn Industries, LLC.
2. Source Limitations: Obtain water closets from single source from single manufacturer.
3. Bowl:
 - a. Material: Vitreous china.
 - b. Type: Siphon jet.
 - c. Style: Flushometer valve.
 - d. Mounting Height: See fixture schedule on drawings.
 - e. Rim Contour: Elongated.
 - f. Water Consumption: Maximum 1.28 gal. (4.8 L) per flush.
 - g. Spud Size and Location: NPS 1-1/2 (DN 40); top.
 - h. Color: White.
4. Flushometer Valve: See flushometer valve paragraph.
5. Toilet Seat: See toilet seat paragraph below.
6. Support: See Water-closet carrier paragraph below.

B. Water Closets - Wall Mounted, Back Outlet, Close-Coupled Flushometer Tank:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Mansfield Plumbing Products LLC.
2. Source Limitations: Obtain water closets from single source from single manufacturer.
3. Bowl:
 - a. Material: Vitreous china.

- b. Type: Siphon jet.
 - c. Style: Flushometer tank, gravity.
 - d. Height: See fixture schedule on drawings.
 - e. Rim Contour: Elongated.
 - f. Water Consumption: Maximum 1.28 gal. (4.8 L) per flush.
 - g. Color: White.
- 4. Toilet Seat: See toilet seat paragraph below.
 - 5. Support: See Water-closet carrier paragraph below.

2.3 FLUSHOMETER VALVES

A. Flushometer Valves - Diaphragm, Solenoid Actuated:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sloan Valve Company.
 - b. Zurn Industries, LLC.
- 2. Source Limitations: Obtain flushometer valve from single source from single manufacturer.
- 3. Minimum Pressure Rating: 125 psig (860 kPa).
- 4. Features: Include integral check stop and backflow-prevention device.
- 5. Material: Brass body with corrosion-resistant components.
- 6. Style: See plumbing drawing fixture schedule.
- 7. Exposed Flushometer-Valve Finish: Chrome-plated.
- 8. Panel Finish: Chrome-plated or stainless steel (For concealed style).
- 9. Actuator: Side or top mounted; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- 10. Trip Mechanism: Battery-powered electronic sensor unless otherwise noted as hard-wired in the plumbing drawing fixture schedule; listed and labeled as defined in NFPA 70, by qualified testing agency, and marked for intended location and application.
- 11. Consumption: Maximum 1.28 gal. (4.8 L) per flush. See plumbing drawing fixture schedule.
- 12. Minimum Inlet: NPS 1 (DN 25).
- 13. Minimum Outlet: NPS 1-1/4 (DN 32).

2.4 TOILET SEATS

A. Toilet Seats:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Bemis Manufacturing Company.
 - c. Centoco Manufacturing Corporation.
 - d. Church Seats; Bemis Manufacturing Company.
 - e. Kohler Co.
 - f. TOTO USA, INC.
 - g. Zurn Industries, LLC.
- 2. Source Limitations: Obtain toilet seat from single source from single manufacturer.
- 3. Material: Plastic.
- 4. Type: Commercial (Heavy duty).
- 5. Shape: Elongated rim, open front.
- 6. Hinge: Self-sustaining, check.

7. Hinge Material: Noncorroding metal.
8. Seat Cover: Not required.
9. Color: White.
10. Surface Treatment: Antimicrobial.

2.5 SUPPORTS

A. Water-Closet Carrier:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. MIFAB, Inc.
 - c. WATTS.
 - d. Zurn Industries, LLC.
2. Source Limitations: Obtain water-closet carrier from single source from single manufacturer.
3. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water-supply piping and sanitary drainage and vent piping systems to verify actual locations of piping connections before water-closet installation.
- B. Examine walls and floors for suitable conditions where water closets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Water-Closet Installation:

1. Install level and plumb.
2. Install accessible, wall-mounted water closets at mounting height in accordance with ICC A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
4. Measure support height installation from finished floor, not structural floor.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.

3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
 4. Install actuators in locations easily reachable for people with disabilities.
- D. Install toilet seats on water closets.
- E. Wall Flange and Escutcheon Installation:
1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
 2. Install deep-pattern escutcheons if required to conceal protruding fittings.
 3. Comply with escutcheon requirements specified in Section 22 0518 "Escutcheons for Plumbing Piping."
- F. Joint Sealing:
1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
 2. Match sealant color to water-closet color.
 3. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."

3.3 PIPING CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 22 1116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 1316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate to be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
 2. Nameplate to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 26 0523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.

3.7 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 22 4216.13 - COMMERCIAL LAVATORIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Vitreous-china, wall-mounted lavatories.
 - 2. Automatically operated lavatory faucets.
 - 3. Supply fittings.
 - 4. Waste fittings.
 - 5. Lavatory supports.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For water consumption.
 - 2. Plumbing Fixtures: Provide the following:
 - a. Manufacturer cut sheet indicating water consumption.
 - b. WaterSense certification for residential fixtures, commercial water closets, commercial urinals, and commercial showers.
- C. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of automatic faucets.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- A. Lavatory - Vitreous China, Wall Mounted:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. TOTO USA, INC.
 2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: For wall hanging.
 - c. Color: White.
 - d. Mounting Material: Wall carrier.
 3. Support: Type II, concealed-arm lavatory carrier with escutcheons.
 4. Lavatory Mounting Height: Handicapped/elderly in accordance with ICC A117.1.
 5. Support: Type III lavatory carrier with two hanger plates made for corner lavatories.
- B. Lavatory Mounting Height: Handicapped/elderly in accordance with ICC A117..

2.2 AUTOMATICALLY OPERATED LAVATORY FAUCETS

- A. NSF Standard: Comply with NSF 61 and NSF 372 for faucet materials that will be in contact with potable water.
- B. Lavatory Faucets - Automatic Type: Hardwired Electronic Sensor Operated:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. Sloan Valve Company.
 2. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
 5. Body Material: Commercial, solid-brass, or die-cast housing with brazed copper and brass waterway.
 6. Finish: Polished chrome plate.
 7. Maximum Flow Rate: 0.35 gpm (1.5 L/min.).
 8. Drain: Not part of faucet.

2.3 SUPPLY FITTINGS

- A. Products shall comply with the SDWA (Safe Drinking Act) "No Lead" restrictions of ANSI NSF 61 and NSF 372 for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.

- C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless steel wall flange.
- D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with brass stems and shall contain no plastics.
- E. 1/2" IPS inlet connection and outlet 3/8" compression.
- F. Operation: Loose key

2.4 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with offset and straight tailpiece.
 - 1. Size: NPS 1-1/4 (DN 32)
 - 2. Material:
 - a. Chrome plated cast brass strainer (with or without overflow) and brass lock nut.
 - b. 17-gauge seamless brass tube drain tailpiece.
 - c. CSA certified or other recognized third party testing authority.
 - d. Marked with manufacturers name.
- C. Trap:
 - 1. Size: NPS 1-1/2 by NPS 1-1/4 (DN 40 by DN 32).
 - 2. Material:
 - a. Chrome plated heavy cast brass with cleanout.
 - b. 17-gauge seamless brass adjustable wall bend.
 - c. Include cast brass, slip joints nuts and no reducing washers.
 - d. CSA certified or other recognized third party testing authority.

2.5 LAVATORY SUPPORTS

- A. Lavatory Wall Carrier:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. WATTS.
 - c. Zurn Industries, LLC.
 - 2. Standard: ASME A112.6.1M.
 - 3. General: Provide with steel uprights and floor anchors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before lavatory installation.
- B. Examine counters and walls for suitable conditions where lavatories will be installed.

- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install lavatories level and plumb in accordance with roughing-in drawings.
- B. Install wall carriers, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, in accordance with ICC A117.1.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 0518 "Escutcheons for Plumbing Piping."
- E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 22 0719 "Plumbing Piping Insulation."

3.3 PIPING CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 22 1116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 1316 "Sanitary Waste and Vent Piping."

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.6 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 22 4216.16 - COMMERCIAL SINKS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Service basins.
 - 2. Utility sinks.
 - 3. Handwash sinks.
 - 4. Sink faucets.
 - 5. Laminar-flow, faucet-spout outlets.
 - 6. Supply fittings.
 - 7. Waste fittings.
- B. Related Requirements:
 - 1. Section 22 4100 "Residential Plumbing Fixtures" for residential sinks.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
 - 2. Include rated capacities, operating characteristics[, **electrical characteristics**,] and furnished specialties and accessories.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted lavatories.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For sinks to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE BASINS

- A. Service Basins: Terrazzo, floor mounted.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Acorn Engineering Company.
- b. Crane Plumbing, L.L.C.
- c. Florestone Products Co., Inc.
- d. Stern-Williams Co., Inc.
2. Fixture:
 - a. Standard: IAPMO PS 99.
 - b. Shape: Square.
 - c. Nominal Size: 24 by 36 inches (610 by 915 mm)
 - d. Height: 12 inches (305 mm) with dropped front.
 - e. Rim Guard: On front] top surface.
 - f. Drain: Grid with NPS 3 (DN 80) outlet.
3. Mounting: On floor and flush to wall.

2.2 UTILITY SINKS

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Tabco.
 - b. Eagle Group; Foodservice Equipment Division.
 - c. Elkay Manufacturing Co.
 - d. Griffin Products, Inc.
 - e. Just Manufacturing.
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Type: Ledge back.

2.3 HANDWASH SINKS

- A. Handwash Sinks: Stainless steel, wall mounted.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Advance Tabco.
 - b. AERO Manufacturing Company.
 - c. Amtekco Industries, Inc.; a Wasserstrom Company.
 - d. Elkay Manufacturing Co.
 - e. Just Manufacturing.
 2. Fixture:
 - a. Standards: ASME A112.19.3/CSA B45.4 and NSF/ANSI 2.
 - b. Type: Basin with radius corners, back for faucet, and support brackets.
 - c. Nominal Size: 17 by 16 by 5 inches (432 by 406 by 127 mm).

2.4 SINK FAUCETS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet-spout materials that will be in contact with potable water.

2.5 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.

- C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

2.6 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece.
- C. Trap:
 - 1. Size: NPS 1-1/2 (DN 40).

2.7 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before sink installation.
- B. Examine walls, floors, and counters for suitable conditions where sinks will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-hung sinks.
- C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
- D. Set floor-mounted sinks in leveling bed of cement grout.
- E. Install water-supply piping with stop on each supply to each sink faucet.

1. Exception: Use ball or gate valves if supply stops are not specified with sink. Comply with valve requirements specified in Section 22 0523.12 "Ball Valves for Plumbing Piping" and Section 22 0523.15 "Gate Valves for Plumbing Piping."
2. Install stops in locations where they can be easily reached for operation.

F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 22 0518 "Escutcheons for Plumbing Piping."

G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 07 9200 "Joint Sealants."

H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 22 0719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 22 1116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 22 1316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 23 0100 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes basic requirements for divisions 22, 23, as well as applicable specification sections in division 26 (variable frequency drives).

1.3 QUALITY ASSURANCE

- A. Where equipment or accessories are used which differ in arrangement, configuration, dimensions, ratings, or engineering parameters from those indicated on the contract documents, the contractor is responsible for all costs involved in integrating the equipment or accessories into the system and for obtaining the performance from the system into which these items are placed. This may include changes found necessary during the testing, adjusting, and balancing phase of the project.
- B. Equipment Design
 - 1. Design equipment and accessories not specifically described or identified by manufacturer's catalog numbers in conformity with applicable technical standards and suitable for maximum working pressure, test pressure and temperatures required.
- C. Equipment Installation
 - 1. Obtain manufacturer's printed installation instructions to aid in properly executing work of installing equipment whenever such instructions are available.
 - 2. Erect equipment in a neat and workmanlike manner. Align, level and adjust for satisfactory operation. Install so that connecting and disconnecting of piping and accessories can be made readily, and so that parts are easily accessible for inspection, operation, maintenance and repair. Minor deviation from arrangements indicated may be made, as approved.
- D. Packaged Equipment
 - 1. Provide packaged equipment, where specified, which is completely factory assembled, including all mechanical and electrical components mounted on a common base or in a common enclosure with all piping, controls and wiring factory installed ready to be incorporated into the mechanical system.
- E. Quietness of Operation
 - 1. Pumps, fans, motors and other equipment with moving parts have been especially selected for quietness of operation.
 - 2. For equipment other than that specified, submitted by the Contractor for approval, submit written statements from the manufacturer and the Contractor that said equipment is at least as quiet as that specified and include certified sound test data to support the claims made.

F. Vibration Isolation

1. Vibration isolation devices for isolating equipment, ductwork and piping from the building structure are specified under Section 23 0548. Procure these devices from a single vibration materials manufacturer through a local representative. Furnish the local representative with copies of Shop Drawings of all equipment requiring vibration isolation and access to the Drawings that show the ductwork and piping that require vibration isolation.
2. For equipment requiring factory installation of vibration isolators, furnish the equipment manufacturer with the identity of the supplier of the vibration isolation manufacturer selected for the Project. Submittals for equipment not equipped with the product of the vibration isolation manufacturer selected for the Project will be rejected.

G. Vibration Testing of Rotating Equipment

1. Pumps

- a. Provide for the services of a qualified vibration consultant to take vibration velocity measurements on all base mounted pumps in accordance with ANSI H11.4.6.
- b. Take measurements on the bearing caps of each pump with a driver 5 HP and larger in the vertical, horizontal and axial directions.
- c. Maximum allowable self-excited, total unfiltered vibration velocity: 0.0875 mm (3.5 mils) per second peak to peak. If the measured velocity exceeds this figure, determine the source of the vibration and make the necessary corrections to bring the velocity figure to within the specified maximum.
- d. Submit on approved data sheets the vibration measurements for each pump along with the relevant charts and data from ANSI H19.6.4.

2. Fans

- a. Provide the services of a qualified vibration consultant to take vibration velocity measurements on all base mounted or suspended fans in accordance with AMCA 204-6.1.
- b. Take measurements on the bearing caps of each fan in the vertical, horizontal and axial directions.
- c. The following table, taken from AMCA 204, lists the fan application categories for the maximum allowable self-excited, total unfiltered, peak-to-peak vibration velocity.

1)	Fan Application Category	IN./S
2)	BV-1	0.60
3)	BV-2	0.30
4)	BV-3	0.20
5)	BV-4	0.15
6)	BV-5	0.10

- d. Apply Fan Application Category BV-3 for fan drivers 5 HP to 25 HP and BV-4 for fan drivers 30 HP and larger. Fans less than 5 HP do not require testing.
- e. If fan vibrations exceed the AMCA allowable levels for the specified vibration category, make the necessary corrections to bring the vibrations to within the allowable levels.

1.4 SEQUENCING AND SCHEDULING

- A. Coordinate mechanical equipment installation with other building components.

- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components, as they are constructed.
- D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.
- E. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.
- F. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

1.5 COORDINATION

- A. Furnish one can of touch up paint for each different color factory finish which is to be the final finished surface of the product. Deliver touch up paint with other "loose and detachable parts" as covered in the General Requirements. Motor controllers.
 - 1. Use zinc rich paint on galvanized surfaces prior to providing finish coat.
- B. Seal and firestop all penetrations of fire rated partitions.
 - 1. Sealing and firestopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

1.6 REFERENCE TO DESIGN DRAWING STANDARDS

- A. Maximum and minimum requirements
 - 1. Refer to equipment schedules for equipment identification number and corresponding area location, capacity, and design requirements.
 - 2. Where ever schedules or notes appear in the Contract Documents in which sizes and capacities of equipment are indicated or specified, provide equipment under the contract which meets the following requirements under operating conditions:
 - a. The RPM, the outlet velocities, tip speeds and the NC ratings specified are the maximum that will be accepted.
 - b. The cfm, the static pressure on fans, the gpm and the total head on pumps, are the minimum that will be accepted.

3. Motor horsepower ratings specified or shown: the minimum acceptable indicated; motor speeds: the maximum acceptable. If a motor is provided having a larger horsepower rating than specified, provide the associated increased wire, breaker, starter, fuses, overload protection, etc., at no additional cost. Provide the increased motor circuit in accordance with the "Motor Circuit Sizing Schedule" indicated. Do not provide increased motor horsepower which together add more than 5 percent to the load of an electrical distribution equipment item (i.e., Motor Control Center, Power Panel, etc.).

1.7 OPERATION AND MAINTENANCE DATA

- A. All operations and maintenance data shall comply with the submission and content requirements specified under section Division 01.
- B. In addition to the general content specified under General Requirements, supply the following additional documentation.
 1. Records of tests performed to certify compliance with system requirements.
 2. Certification of inspections by regulatory agencies.
 3. Valve schedules.
 4. Lubrication instructions, including list/frequency of lubrication.

1.8 CERTIFICATIONS AND INSPECTIONS

- A. Obtain and pay for all required installation inspections except those provided by the Architect/Engineer. Include copies of the certificates in the Operating and Maintenance Manuals.

1.9 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Provide 2 copies of O&M manuals in three ring or post binders, using an index at the front of each volume and tabs for each system or type of equipment. Provide an electronic PDF of the same material.
 1. Prior to printing the O&M documents provide electronic PDF documents to the architect for approval. PDF documents shall be organized identical to the intended layout of the 3-ring binders. Provide digital bookmarks for each piece of equipment, similar to the indexed layout of the 3-ring binder.
- B. In addition to the data indicated in the General Requirements, include the following information:
 1. Copies of all approved shop drawings.
 2. Manufacturer's wiring diagrams for electrically powered equipment.
 3. Records of tests performed to certify compliance with system requirements.
 4. Certificates of inspection by regulatory agencies.
 5. Temperature control record drawings and control sequences.
 6. Parts lists for manufactured equipment.
 7. Valve schedules.
 8. Lubrication instructions, including list/frequency of lubrication done during construction
 9. Warranties.
 10. Additional information as indicated in the technical specification sections.

1.10 TRAINING OF OWNER PERSONNEL

- A. Instruct Owner personnel in the proper operation and maintenance of systems and equipment provided as part of this project; video tape all training sessions. Use hours indicated in individual specification sections. Where hours are not indicated within an individual specification section, include not less than 4 hours of instruction for each piece of equipment, using the Operating and Maintenance manuals during this instruction. Demonstrate startup and shutdown procedures for all equipment. All training to be during normal working hours.

1.11 RECORD DRAWINGS

- A. In addition to the data indicated in the General Requirements, maintain temperature control record drawings on originals prepared by the installing contractor/subcontractor. Include copies of these record drawings with the Operating and Maintenance manuals.

PART 2 - PRODUCTS

2.1 ACCESS PANELS AND DOORS

- A. Lay-in Ceilings
 - 1. Removable lay in ceiling tiles in 2 X 2 foot or 2 X 4 foot configuration provided under Division 9 are sufficient; no additional access provisions are required unless specifically indicated.
 - a. Provide tagging system using colored dots for identifying where equipment is located above the ceiling. Coordinate coloring system with Owner.
 - 2. Plaster walls and ceilings
 - a. 16 gauge frame with not less than a 20 gauge hinged door panel, prime coated steel for general applications, stainless steel for use in toilets, showers, and similar wet areas, concealed hinges, screwdriver operated cam latch for general applications, key lock for use in public areas, UL listed for use in fire rated partitions if required by the application. Use the largest size access opening possible, consistent with the space and the equipment needing service; minimum size is 12" by 12".

2.2 SEALING AND FIRESTOPPING

- A. Fire and/or Smoke Rated Penetrations
 - 1. Manufacturers: Subject to compliance with the requirements, provide products by one of the following:
 - a. 3M
 - b. Hilti,
 - c. Rectorseal,
 - d. STI/SpecSeal
 - e. Tremco
 - 2. General
 - a. Fire stop systems shall be UL listed or tested by an independent testing laboratory approved by the Department of Commerce.
 - b. Use a product that has a rating not less than the rating of the wall or floor being penetrated. Reference architectural and life safety drawings for identification of fire and/or smoke rated walls and floors.

- c. Contractor shall use firestop putty, caulk sealant, intumescent wrap strips, intumescent firestop collars, firestop blocks, firestop mortar or a combination of these products to provide a UL listed system for each application required for this project. Provide mineral wool backing where specified in manufacturer's application detail.
- B. Non-Rated Penetrations
 - 1. Pipe Penetrations
 - a. At pipe penetrations of non-rated interior partitions, floors and exterior walls above grade, use urethane caulk in annular space between pipe insulation and sleeve. For non-rated drywall, plaster or wood partitions where sleeve is not required use urethane caulk in annular space between pipe insulation and wall material.
 - 2. Duct Penetrations
 - a. Annular space between duct (with or without insulation) and the non-rated partition or floor opening shall not be larger than 2".
 - b. Where shown or specified, pack annular space with fiberglass batt insulation or mineral wool insulation. Provide 4" sheet metal escutcheon around duct on both sides of partition or floor to cover annular space.

PART 3 - EXECUTION

3.1 ERECTION, INSTALLATION, APPLICATION

- A. Dimension and Design
 - 1. Provide apparatus and equipment of such dimensions and design as to be adapted to the arrangement of the installation and to fit within the limits of the space available.
- B. Stand-off Brackets
 - 1. Provide insulated equipment, piping and duct work with stand-off brackets for attaching components to allow full insulation thickness.
- C. Special Tools
 - 1. Provide tools required to operate, adjust, or make minor repairs to the equipment and install them in a wall mounted wood or metal case. Provide the case with a lock and two keys.
- D. Standard Products
 - 1. Provide products and equipment that are essentially the standard product of the manufacturer. Where two or more units of the same product or type of equipment are required, provide these units as products of the same manufacturer.
 - 2. Where the requirements of the Contract Documents exceed that of a manufacturer's standard product in terms of quality, performance or efficiency, the manufacturer shall make special provisions to ensure that the product proposed meets the requirements of the Contract Documents.
- E. Substituted Items
 - 1. Should a substitute item be offered and accepted and the substitute item requires services or utilities other than required by the item substituted for, provide those other services or utilities at no additional cost to the Owner.

F. Equipment Locations

1. Mechanical equipment and devices have been shown on the Drawings in the approximate location required for reasons of access, noise control or maintainability. Minor adjustments in location dictated by coordination with other work are permitted. Major relocations for reasons other than these are not to be made without specific written approval.

G. Interferences

1. Before proceeding with the installation of piping and ductwork, inspect the Contract Documents and determine that the location of the Work does not interfere with other work. In case of interference request clarification from the Architect in writing.

H. Holes Through Previously Constructed Walls and Floors

1. Cut holes for the passage of piping and ductwork through previously constructed walls and floors in a neat workman-like manner.
2. Make holes through floors and masonry walls by coring or saw-cutting the hole with minimum oversizing to allow for firesafing or caulking the peripheral space between the pipe or duct and the structure.
3. Make holes through gypsum board walls by sawing with minimum oversizing to allow for firesafing or caulking or for a flange or escutcheon to be placed in a manner to fill or cover the peripheral space between the pipe or duct and the wall.

I. Piping and Ductwork – Prohibited Locations

1. Do not run piping over electrical equipment such as transformers, switchgear and panelboards.
2. When possible, do not install piping and ductwork of any kind in Electrical Rooms, telecommunications rooms, or elevator equipment rooms, except that which serves these rooms.
3. If installing piping or ductwork in Electrical rooms cannot be avoided, maintain a clear space over the equipment and 36 inches in front of equipment from floor to ceiling.

J. Offsets and Transitions

1. In general, most main offsets and transitions of piping and duct work are shown on the drawings in order to indicate approximate locations in plan and elevation where the systems are intended to be run.
2. The Contract Documents are not intended to serve as coordinated construction drawings showing all minor adjustments in locations and duct cross sections that are required for a fully coordinated installation that respects the work of all trades.
3. Fully coordinate the mechanical work within itself and with the work of other trades to ensure the avoidance of all interferences.

K. Lines and Grades

1. Construct Work in conformity with lines and grades as indicated.
2. Lay out the Work and be responsible for lines, elevations and measurements required for the installation of the Work.
3. Space axis lines within building on each floor level so that mechanical work may be laid out with metal tape measure having length of 30.5 meters (100 feet) maximum. The use of cloth tape for lay-out will not be permitted.
4. Use bench marks outside building from which lines and grades required for installation of mechanical work may be set.

L. Fan Inlet and Outlet Guards

1. Provide screen guards with rigid angle frames on fan inlet and outlet openings which are accessible to personnel.

3.2 CUTTING AND PATCHING

- A. Refer to Division 1 for cutting and patching requirements.

3.3 CONCRETE WORK

- A. Provide cast in place concrete per Division 3 requirements. Provide all layout drawings, anchor bolts, metal shapes, and/or templates required to be cast into concrete or used to form concrete for support of mechanical equipment.

3.4 SEALING AND FIRESTOPPING

A. Fire and/or Smoke Rated Penetrations

1. Install approved product in accordance with the manufacturer's instructions where pipes penetrate a fire/smoke rated surface. When pipe is insulated, use a product which maintains the integrity of the insulation and vapor barrier.
2. Where firestop mortar is used to infill large fire-rated floor openings that could be required to support weight, provide permanent structural forming. Firestop mortar alone is not adequate to support any substantial weight.

B. Non-Rated Partitions

1. In exterior wall openings below grade, assemble rubber links of mechanical seal to the proper size for the pipe and tighten in place, in accordance with manufacturer's instructions.
2. At all interior partitions and exterior walls, pipe penetrations are required to be sealed. Apply sealant to both sides of the penetration in such a manner that the annular space between the pipe sleeve or cored opening and the pipe or insulation is completely blocked.

- C. Duct penetrations through non-rated partitions shall require sheet metal escutcheons with fiberglass or mineral wool insulation fill for spaces that include laboratories, kitchens/servery, janitor closets, toilet rooms, mechanical rooms, conference rooms, private consultation rooms, and where noted on drawings elsewhere.

- D. Sealing and firestopping of sleeves/openings between ductwork, piping, etc. and the sleeve, structural or partition opening shall be the responsibility of the contractor whose work penetrates the opening. The contractor responsible shall hire individuals skilled in such work to do the sealing and fireproofing. These individuals hired shall normally and routinely be employed in the sealing and fireproofing occupation.

END OF SECTION

SECTION 23 0413 - COMMON SUBMITTAL REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes supplementary administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals specific to the work of this Division.
- B. Related Requirements:
 - 1. Division 01 submittal requirements.

1.2 DEFINITIONS

- A. Contractor: Refers to an entity in direct Contract with the Owner to furnish and/or perform any portion of the Work of the Contract, including but not limited to a Construction Manager.
 - 1. Contractor shall review and approve Product Submittals prior to forwarding them to the Architect.
- B. Product Submittals: In general, Product Submittals show characteristics of the proposed construction in one of the following forms:
 - 1. Shop Drawings.
 - 2. Product Data.
 - 3. Samples.
- C. Action Submittals: Written and graphic information and physical samples that require Architect's and Construction Manager's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."
- D. Informational Submittals: Written and graphic information and physical samples that do not require Architect's and Construction Manager's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."
- E. Submittal Review Sheet: Specific form required to accompany each submittal. Obtain Submittal Review Sheet from the SmithGroup Project Manager.

1.3 SUBMITTAL ADMINISTRATIVE REQUIREMENTS

- A. Requirements specified for submittals are intended to provide efficient handling, while permitting review responsibilities to be carried out.
- B. Avoidable Resubmittals: The first two reviews of each specified submittal will be processed without cost to the Contractor. After the second review, the Owner may charge the Contractor for the cost of such additional processing, unless the processing results from approved Change Orders causing revisions to previously approved submittals.
- C. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.

1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
 2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
 3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
 4. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
 - a. Architect and Construction Manager reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
- D. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Architect's Construction Manager's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
1. Initial Review: Allow 10 business days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required.
 2. When a large volume of submittal materials is scheduled, additional review time may be required. Similarly, a particular submittal may require review completion in less than the agreed normal time. Due to variations in submittal volume and processing needs, agreed review time is not intended to apply to extreme conditions.
 3. Resubmittal Review: Allow 10 business days for review of each resubmittal.
 4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow 15 business days for initial review of each submittal.
- E. Maintain at the Project Site ready access to the latest reviewed Shop Drawings and Product Data, and one set of samples.
- 1.4 DELEGATED-DESIGN SERVICES
- A. Definitions:
1. Delegated Design: A portion or component of the Work identified by the Contract Documents to be designed by the Contractor, or an entity assigned by the Contractor, to satisfy performance and design criteria specified in the Contract Documents for that portion or component.
 2. Registered Design Professional: Design professional, assigned by the Contractor, who is responsible for providing the delegated design work, and for certifying that the work is in compliance with the specified performance requirements and design criteria. Design professional shall be legally qualified to practice in jurisdiction where Project is located and shall be experienced in providing delegated design services of the kind indicated. Delegated design services are defined as those performed for installation of the system, assembly or product that are similar in material, design, and extent to those indicated for this Project.
- B. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Architect.
- C. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF electronic file copies of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.
 1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

- A. Action and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Combine with Submittal Review Sheet before submitting to Architect and Construction Manager.
 1. Submittal Compliance Form: Allowed in lieu of some product data and sample submittals. See individual specification sections for specific allowable use. By submitting the form, the Contractor certifies that all products specified in the Section are being submitted exactly as indicated, including all options and features indicated, with no substitutions or comparable products. Where a Basis-of-Design manufacturer/product is indicated, along with a list of other manufacturers, the Contractor certifies that only the Basis-of-Design manufacturer/product will be provided and not any other listed manufacturers/products. Where a single manufacturer/product is indicated, even if specified as "available manufacturer" or manufacturer "included but not limited to the following", Contractor certifies that only the indicated single manufacturer/product will be provided.
 - a. Obtain a copy of the Submittal Compliance Form from the Architect, fill in the information required and include as a line item on the Submittal Cover Sheet for each applicable Submittal.
 - b. Upon receipt, the Architect will complete the form in the space below "Architect Action" and indicate the Action on the Submittal Cover Sheet.
- B. Project Closeout and Maintenance Material Submittals: See requirements in Division 01.
- C. Be responsible for quantities, weights, and dimensions to be confirmed and correlated at the site; for information that pertains solely to the fabrication processes and to the means, methods, techniques, sequences, and procedures of construction; and for coordination of the work of every trade, supplier, and subcontractor.
- D. Be responsible for each submittal to be in conformance with information given and the design intent expressed in the Contract Documents.

- E. Provide with each submittal specific written notice of any variation from the requirements of the Contract Documents by causing a specific notation to be made on the Submittal Review Sheet and Submittal Transmittal.

3.2 ARCHITECT'S AND GENERAL CONTRACTOR'S ACTION

- A. General: Architect will not review submittals that do not include the Submittal Review Sheet.
- B. Action Submittals: Architect's staff and consultants will review the submittal, and mark the Submittal Review Sheet with an action code. The code meanings are described below.
- C. Additional codes may be provided within comments or as an electronic submittal review stamp and shall be used in help indicating return of partial submittals.
- D. The Final Review Code on the Submittal Review Sheet prevails and governs the action of the overall submittal.
- E. Review Code meanings are as follows:
 - 1. Action Codes Permitting Use:
 - a. When an action code permitting use is assigned to a submittal, it does not authorize work that does not comply with the requirements of the Contract Documents. Acceptance of the Work will depend on compliance.
 - b. Code AP - Approved: The Work covered by the submittal item may proceed, provided it complies with Contract Document requirements.
 - c. Code AN - Approved as Noted: The Work covered by the submittal item may proceed, provided it complies with the Architect's notations and Contract Document requirements.
 - d. Code AN-R - Approved as Noted - Resubmit: Do not deliver or install the related work until the resubmittal has received Code AP or AN. However, fabrication and other off-site work covered by the submittal item may proceed, at the Contractor's risk, provided it complies with the Architect's notations and Contract Document requirements.
 - 2. Action Code Prohibiting Use:
 - a. Action Code REJ - Not Approved: The Work covered by the submittal item, including purchasing, fabrication, delivery, and other activity, shall not proceed. Revise the submittal item or prepare a new item in accordance with the Architect's notations. Resubmit the corrected or new item without delay; do not permit submittal items marked "Not Approved" to be used. Work incorporating such items will be rejected.
 - 3. Action Code for Items Not Required:
 - a. Action Code X - Not Requested by Contract Documents: The submittal item is not called for by the Contract Documents and is being returned unreviewed by the Architect except to the extent necessary to determine its status.
- F. Informational Submittals: For Architect's information only. Architect and Construction Manager will review each submittal and will not return it, or will return it if it does not comply with requirements. Architect and Construction Manager will forward each submittal to appropriate party.
 - 1. Action Code for Information Only:

- a. Action Code INF - Information Only - Received: The submittal item is not called for a return with a reviewed action code by the Contract Documents and is being returned un-reviewed by the Architect except to the extent necessary to determine its status.
- G. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Architect.
- H. Incomplete submittals are not acceptable, will be considered non-responsive, and will be returned without review.
- I. Architect and Construction Manager will return without review or discard submittals received from sources other than the Contractor.
- J. Submittals not required by the Contract Documents may be returned by the Architect without action.
 - 1. Do not submit Material Safety Data Sheets. They will be returned without review.

3.3 SUBMITTAL TRANSMITTAL REQUIREMENTS

- A. Submittal Transmittal shall be a PDF file in electronic format. It is recommended, to expedite the submittal review, the electronic form be emailed for review to the Architect as early as possible.
 - 1. Submittal Numbering: See below.
 - 2. Contact Information: Full Name, Phone Number and Email Address.
- B. Submittal Definition
 - 1. Each submittal consists of items from only ONE Specifications section.
 - 2. Complete Submittal: If ALL the items required by the Specifications section are listed on one Submittal Form (including continuation sheet), it is a complete submittal.
 - 3. Partial Submittals: If it is necessary to divide the required items of a given Specifications section into two or more submittals to meet schedule or handling requirements, the separate submittals are partial submittals. All partial submittals have the same submittal number, and are differentiated by sequential P-numbers (see below).
 - 4. All items in each submittal, whether complete or partial, will be processed together: Individual items will not be 'broken out' for special handling. Arrange submittals accordingly.
- C. Submittal Numbering
 - 1. Number submittals as described below to assist tracking.
 - 2. Number each submittal in the format nnnnnn-pp.
 - a. The 6-digit number is the number of the section that requires the submittal. For example, 044200.
 - b. The 2-digit number is based on the numerical sequence of submittals from that section. In other words, for each section, the first submittal is 01, the second is 02, and so on. The 2-digit number does not change for partial or re-submittals, so that the submittal can be tracked.
 - c. P-Number for Partial Submittals: Number each partial submittal in the pee space, beginning with P1, and increasing by one for each partial submittal of that submittal. If the submittal is a complete submittal, leave the P space blank.

- d. R-Number for Re-submittals: Number each re-submittal in the arr space, beginning with R1, and increasing by one for each re-submittal of that submittal. Do not include an R-Number for the initial submittal.
- e. Examples:
 - 1) Initial Complete Submittal: 044200-01. First Re-Submittal: 044200-01-R1.
 - 2) Initial Partial Submittal: 044200-01-P1. Second Partial Submittal: 044200-01-P2.
 - 3) First Re-submittal of Second Partial Submittal: 044200-R1-P2.

3.4 SUBMITTAL REVIEW SHEET REQUIREMENTS

- A. Provide Submittal Review Sheet in PDF format. Submit as the page after the Submittal Transmittal.
- B. When attached, the Submittal Review Sheet shall not obscure information contained in the submittal.
- C. Do not edit any of the information contained within the Submittal Review Sheet except as follows:
 - 1. Submittal Number: See Submittal Numbering in Submittal Transmittal Requirements paragraph.
- D. The Contractor shall submit the PDF file in a manner that will allow editing of the Submittal Review Sheet fields by SmithGroup and its consultants.

END OF SECTION

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS**2.1 GENERAL MOTOR REQUIREMENTS**

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.
- C. EC motor line filter requirements: Provide passive filtering components as required to limit total harmonic voltage distortion (THDv) and total harmonic current distortion (THDi) caused by electronically commutated motors (ECM) and/or loads controlled by silicon controlled rectifiers (SCR) to 5% and 20% respectively. The specified THD performance shall be achieved with the attached motor operating throughout its entire speed and load ranges, with the input voltage to the motor controller at the nominal line voltage. The point of measurement for the specified THD performance shall be at the electrical panelboard where the ECM/SCR branch circuit connects to the power distribution system. The manufacturer shall provide additional line conditioning equipment, if necessary, to meet this requirement. Provide wiring diagram documentation indicating installed location of filtration.
- D. Provide a maintenance free, circumferential conductive micro fiber grounding ring installed on the AC motor to discharge shaft currents to ground. Grounding ring shall be AEGIS SGR (Shaft Grounding Ring).
- E. Motors protected by the AEGIS SGR shall be warranted for the term of the manufacturer's motor warranty from induced bearing current damage.

- F. Motors up to 100 HP shall be provided with a shaft grounding ring installed on either the drive end or non-drive end. Motors over 100 HP shall be provided with an insulated bearing on the non-drive end and a shaft grounding ring on the drive end of the motor. Grounding rings shall be provided and installed by the motor manufacturer or contractor and shall be installed in accordance with the shaft grounding ring manufacturer's recommendations.
- G. All motors operated on variable frequency drives shall be bonded from the motor foot to system ground with a high-frequency ground strap made of flat braided tinned copper with terminations to accommodate motor foot and system ground connection.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ELECTRONICALLY COMMUTATED (EC) MOTORS

- A. Description: EC, variable-speed, dc, programmable brushless motor.
- B. Features:
 - 1. Integral controller/inverter operates wound stator and senses rotor position to electronically commute the stator.
 - 2. Controller shall control motor speed through a remote 0- to 10-V-dc control signal.
 - 3. Motor Mounting: Coordinate with driven equipment; suitable for mounting with motor shaft in either horizontal or vertical position.

- C. Performance:
1. Altitude: Suitable for operation at site altitude.
 2. Electrical Characteristics: Suitable for operation with field power source. Coordinate with electrical Installer.
 3. Energy Efficiency: Complying with governing energy codes; 80 percent or higher maintained throughout entire operating range.
 4. Power Factor: 0.9 or higher at full load.
 5. Service Factor: 1.0 or higher.
 6. Speed Control: Variable, zero to 100 percent.
 - a. Synchronous speed rotation with no slip losses.
 - b. Gradual ramp-up to set point upon receiving a start signal.
 - c. Soft speed change ramps.
 - d. Able to overcome reverse rotation without impact.
 - e. Control airflow within 5 percent of set point regardless of static pressure.
 7. Temperature: Suitable for operation in ambient temperature range encountered.
 8. Thermal Protection:
 - a. Automatically breaks electrical power to motor when temperature exceeds a safe value.
 - b. Automatically resets and restores power when temperature returns to normal range.
- D. Bearings: Sealed and permanently lubricated ball bearings.
- E. Enclosure: ODP or TEFC.
- F. Insulation: Class B or Class F.
- G. Rotor: Permanent magnet with near zero rotor losses that operates independent of motor current.
- H. Materials and Construction:
1. Enclosure and Frame: Aluminum, painted steel, or stainless steel.
 2. End Brackets: Cast aluminum..Motor Leads: Pin or screw terminals.
 3. Shaft: Steel or stainless steel.
 4. Motor Leads: Pin or screw terminals.
 5. Nameplates: Manufacturer's standard.
 6. Paint: Manufacturer's standard.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 23 0516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Packless expansion joints.
 - 2. Grooved-joint expansion joints.
 - 3. Alignment guides and anchors.
- B. Related Requirements:
 - 1. Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated Design Submittals: For each anchor, expansion joint, and alignment guide provide the following that is signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, anchors, alignment guides and swing connections. Design shall accommodate thermal expansion and contraction in accordance with:
 - a. ASME B31.1 for power piping systems
 - b. ASME B31.9 for building services piping
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Provide products suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Provide products and installations that will accommodate maximum axial movement as scheduled or indicated on Drawings.
- C. Provide structural work and equipment required for expansion and contraction of piping. Verify anchors, guides, and expansion joints provide and adequately protect system.
- D. Fluid Design Criteria
 - 1. Hot Water Heating System : 30% Propylene Glycol
 - 2. Chilled Water System : 30% Propylene Glycol
 - 3. Energy Recovery System : 30% Propylene Glycol
 - 4. Low Pressure Steam System (Humidifier) : 100% Water
- E. Expansion Compensation Design Criteria:
 - 1. Installation Temperature: 46 degrees F.
 - 2. Hot Water Heating System Temperature: 130 degrees F.
 - 3. Low Pressure Steam System Temperature: 250 degrees F and 0 psig.
 - 4. Chilled Water System Temperature: 57 degrees F.
 - a. Mason Industries, Inc.
 - b. Mason Industries, Inc.

2.2 PACKLESS EXPANSION JOINTS

- A. Metal, Compensator Packless Expansion Joints: MCEJ-01.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex-Weld; a division of Kelco.
 - d. Hyspan Precision Products, Inc.
 - e. Mason Industries, Inc.
 - f. Metraflex Company (The).
 - 2. Source Limitations: Obtain metal compensator packless expansion joints from single manufacturer.
 - 3. Minimum Pressure Rating: 150 psig (1035 kPa) unless otherwise indicated.
 - 4. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
 - 5. Joint Axial Movement: 2 inches (50 mm) of compression and 1/2 inch (12 mm) of extension.
 - 6. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.

7. Configuration for Steel Piping: Multi-ply, stainless steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.
- B. Rubber Union Connector Expansion Joints: RUEJ-01.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amber/Booth Company, Inc.; a VMC Group Company.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. Flo Fab Inc.
 - e. General Rubber Corporation.
 - f. Kadant Unaflex, LLC.
 - g. Mason Industries, Inc.
 - h. Metraflex Company (The).
 - i. Proco Products, Inc.
 - j. Unisource Manufacturing, Inc.
 2. Source Limitations: Obtain rubber union connector expansion joints from single manufacturer.
 3. Material: Twin reinforced-rubber spheres with external restraining cables.
 4. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
 5. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- C. Flexible-Hose Packless Expansion Joints: FHEJ-01.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex-Pression.
 - d. Flex-Weld; a division of Kelco.
 - e. Kadant Unaflex, LLC.
 - f. Mason Industries, Inc.
 - g. Metraflex Company (The).
 - h. Proco Products, Inc.
 - i. Unisource Manufacturing, Inc.
 2. Source Limitations: Obtain flexible-hose packless expansion joints from single manufacturer.
 3. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 4. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 5. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
 6. Expansion Joints for Steel Piping NPS 2 (DN 50) and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless steel hoses and single-braid, stainless steel sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 325 psig at 600 deg F (2250 kPa at 315 deg C) ratings.

- b. Stainless steel hoses and double-braid, stainless steel sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 515 psig at 600 deg F (3550 kPa at 315 deg C) ratings.
 - 7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6 (DN 65 to DN 150): Carbon steel fittings with flanged end connections.
 - a. Stainless steel hoses and single-braid, stainless steel sheaths with 200 psig at 70 deg F (1380 kPa at 21 deg C) and 145 psig at 600 deg F (1000 kPa at 315 deg C) ratings.
 - b. Stainless steel hoses and double-braid, stainless steel sheaths with 275 psig at 70 deg F (1900 kPa at 21 deg C) and 200 psig at 600 deg F (1380 kPa at 315 deg C) ratings.
- D. Metal-Bellows Packless Expansion Joints: MBEJ-01.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Adasco Manufacturing LLC.
 - b. Badger Industries, Inc.
 - c. Flex-Hose Co., Inc.
 - d. Flexicraft Industries.
 - e. Flex-Pression.
 - f. Flex-Weld; a division of Kelco.
 - g. Flo Fab Inc.
 - h. Hyspan Precision Products, Inc.
 - i. Kadant Unaflex, LLC.
 - j. Metraflex Company (The).
 - k. Proco Products, Inc.
 - l. Senior Flexonics Pathway.
 - m. Tozen Corporation.
 - n. Universal Hose and Braid; a Hyspan Company.
 - o. WahlcoMetroflex.
 - 2. Source Limitations: Obtain metal-bellows packless expansion joints from single manufacturer.
 - 3. Standards: ASTM F1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
 - 4. Type: Circular, corrugated bellows with external tie rods.
 - 5. Minimum Pressure Rating: 200 psig (1379 kPa) unless otherwise indicated.
 - 6. Configuration: Single joint with base and double joint with base class(es), unless otherwise indicated.
 - 7. Expansion Joints for Copper Tubing: Single- or multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - a. End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Solder joint.
 - c. End Connections for Copper Tubing NPS 5 (DN 125) and Larger: Flanged.
 - 8. Expansion Joints for Steel Piping: Single- or multi-ply stainless steel bellows, steel pipe ends, and carbon steel shroud.
 - a. End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 (DN 65) and Larger: Flanged.

2.3 GROOVED-JOINT EXPANSION JOINTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 2. Shurjoint; a part of Aalberts Integrated piping Systems.
 3. Victaulic Company.
- B. Source Limitations: Obtain grooved-joint expansion joints from single manufacturer.
- C. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- D. Standard: AWWA C606, for grooved joints.
- E. Nipples: Galvanized, ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- F. Couplings: 12, flexible type for steel-pipe dimensions. Include ferrous housing sections, EPDM rubber gasket suitable for cold and hot water, and bolts and nuts.

2.4 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides: AG-01.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Mason Industries, Inc.
 - c. Metraflex Company (The).
 2. Source Limitations: Obtain alignment guides from single manufacturer.
 3. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- B. Anchor Materials:
1. Steel Shapes and Plates: ASTM A36/A36M.
 2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
 3. Washers: ASTM F844, steel, plain, flat washers.
 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, stainless steel.
 - b. Expansion Plug: Stainless steel.
 - c. Washer and Nut: Stainless steel.
 5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A307, stainless steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Stainless steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS - GENERAL

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 INSTALLATION OF PACKED EXPANSION JOINTS

- A. Install packed expansion joints with packing suitable for fluid service.

3.3 INSTALLATION OF PACKLESS EXPANSION JOINTS

- A. Install metal-bellows packless expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- B. Install rubber packless expansion joints according to FSA-PSJ-703.

3.4 INSTALLATION OF GROOVED-JOINT EXPANSION JOINTS

- A. Install grooved-joint expansion joints to grooved-end steel piping.

3.5 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9.
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-58, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
 - 3. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.6 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 0517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
- B. Related Requirements:
 - 1. Section 07 8413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. GPT, an EnPro Industries company.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends and integral welded waterstop collar.
- D. Galvanized-Steel Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
- E. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
- F. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

- G. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Jay R. Smith Mfg. Co.
 2. Zurn Industries, LLC.
- B. Description: Manufactured, galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
 4. Metraflex Company (The).
 5. Proco Products, Inc.
- B. Description:
 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 2. Designed to form a hydrostatic seal of 20-psig (137-kPa) minimum).
 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
 4. Metraflex Company (The).
 5. Proco Products, Inc.
- B. Description:
 1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
 2. Plastic or rubber waterstop collar with center opening to match piping OD.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 07 8413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 07 6200 "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 3 inches (76 mm) above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 07 8413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls Above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Steel pipe sleeves.
 - 2. Exterior Concrete Walls Below Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Interior Partitions:
 - a. Piping Smaller Than NPS 6 (DN 150): Steel pipe sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel sheet sleeves.

END OF SECTION

SECTION 23 0518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- B. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 0519 - METERS AND GAUGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Liquid-in-glass thermometers.
 - 2. Duct-thermometer mounting brackets.
 - 3. Thermowells.
 - 4. Dial-type pressure gages.
 - 5. Gage attachments.
 - 6. Test plugs.
 - 7. Test-plug kits.
 - 8. Sight flow indicators.
 - 9. Flowmeters.
 - 10. Thermal-energy meters.
- B. Related Requirements:
 - 1. Section 23 1123 "Facility Natural-Gas Piping" for gas meters.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- a. Weiss Instruments, Inc.
- B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Terice, H. O. Co.
 - b. Weiss Instruments, Inc.
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum; [7-inch (178-mm)] [9-inch (229-mm)] nominal size unless otherwise indicated.

4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 THERMOWELLS

- A. Thermowells:
 1. Standard: ASME B40.200.
 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
 3. Material for Use with Copper Tubing: CNR or CUNI.
 4. Material for Use with Steel Piping: CRES.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length required to match thermometer bulb or stem.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
- B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 DIAL-TYPE PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Terice, H. O. Co.
 - b. Watts; a Watts Water Technologies company.
 - c. Weiss Instruments, Inc.
 2. Standard: ASME B40.100.
 3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 6-inch (152-mm) nominal diameter.
 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 6. Movement: Mechanical, with link to pressure element and connection to pointer.

7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston -type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of stainless-steel pipe with [NPS 1/4 (DN 8)] [NPS 1/4 or NPS 1/2 (DN 8 or DN 15)] [NPS 1/2 (DN 15)] pipe threads.
- C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Trerice, H. O. Co.
 2. Watts; a Watts Water Technologies company.
 3. Weiss Instruments, Inc.
- B. Description: Test-station fitting made for insertion in piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/4 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.7 TEST-PLUG KITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Trerice, H. O. Co.
 2. Watts; a Watts Water Technologies company.
 3. Weiss Instruments, Inc.
- B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

- C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
- D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
- E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
- F. Carrying Case: Metal or plastic, with formed instrument padding.

2.8 SIGHT FLOW INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. John C. Ernst Co., Inc.
 - 2. KOBOLD Instruments, Inc. - USA.
 - 3. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
 - 4. Pentair Valves & Controls; Penberthy Brand.
- B. Description: Piping inline-installation device for visual verification of flow.
- C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
- D. Minimum Pressure Rating: 150 psig (1034 kPa).
- E. Minimum Temperature Rating: 200 deg F (93 deg C).
- F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- G. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- J. Install valve and syphon fitting in piping for each pressure gage for steam.
- K. Install test plugs in piping tees.
- L. Install flow indicators in piping systems in accessible positions for easy viewing.
- M. Install permanent indicators on walls or brackets in accessible and readable positions.
- N. Install connection fittings in accessible locations for attachment to portable indicators.
- O. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Two inlets and two outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Two inlets and two outlets of each hydronic heat exchanger.
 - 6. Inlet and outlet of each thermal-storage tank.
 - 7. Outside-, return-, supply-, and mixed-air ducts.
- P. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - 3. Suction and discharge of each pump.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- B. Thermometers at inlet and outlet of each hydronic boiler shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- C. Thermometers at inlets and outlets of each heat pump / chiller shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- F. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
 - 1. Industrial-style, liquid-in-glass type.
- G. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.
- B. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F and 0 to 150 deg C.
- C. Scale Range for Air Ducts: Minus 40 to plus 160 deg F and minus 40 to plus 100 deg C.

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:
 - 1. Liquid-filled , direct -mounted, metal case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic EPDM self-sealing rubber inserts.
- B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
 - 1. Liquid-filled , direct -mounted, metal case.
 - 2. **[Sealed]** **<Insert type>**, **[direct]** **[remote]**-mounted, plastic case.
 - 3. Test plug with **[chlorosulfonated polyethylene synthetic]** **[EPDM]** self-sealing rubber inserts.

- C. Pressure gages at suction and discharge of each pump shall be[**one of**] the following:
1. **[Liquid-filled] [Sealed] [Open-front, pressure-relief] [Solid-front, pressure-relief]** **<Insert type>**, **[direct] [remote]**-mounted, metal case.
 2. **[Sealed]** **<Insert type>**, **[direct] [remote]**-mounted, plastic case.
 3. Test plug with **[chlorosulfonated polyethylene synthetic] [EPDM]** self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: [30-in. Hg to 15 psi (minus 100 to 0 kPa)] **[30-in. Hg to 15 psi and minus 100 to 0 kPa]**.
- B. Scale Range for Chilled-Water Piping: [0 to 30 psi (0 to 240 kPa)] **[0 to 30 psi and 0 to 240 kPa]**.
- C. Scale Range for Chilled-Water Piping: [0 to 100 psi (0 to 600 kPa)] **[0 to 100 psi and 0 to 600 kPa]**.
- D. Scale Range for Chilled-Water Piping: [0 to 160 psi (0 to 1100 kPa)] **[0 to 160 psi and 0 to 1100 kPa]**.
- E. Scale Range for Chilled-Water Piping: [0 to 200 psi (0 to 1400 kPa)] **[0 to 200 psi and 0 to 1400 kPa]**.
- F. Scale Range for Chilled-Water Piping: [0 to 300 psi (0 to 2500 kPa)] **[0 to 300 psi and 0 to 2500 kPa]**.
- G. Scale Range for Chilled-Water Piping: [0 to 600 psi (0 to 4000 kPa)] **[0 to 600 psi and 0 to 4000 kPa]**.
- H. Scale Range for Condenser-Water Piping: [30-in. Hg to 15 psi (minus 100 to 0 kPa)] **[30-in. Hg to 15 psi and minus 100 to 0 kPa]**.
- I. Scale Range for Condenser-Water Piping: [0 to 30 psi (0 to 240 kPa)] **[0 to 30 psi and 0 to 240 kPa]**.
- J. Scale Range for Condenser-Water Piping: [0 to 100 psi (0 to 600 kPa)] **[0 to 100 psi and 0 to 600 kPa]**.
- K. Scale Range for Condenser-Water Piping: [0 to 160 psi (0 to 1100 kPa)] **[0 to 160 psi and 0 to 1100 kPa]**.
- L. Scale Range for Condenser-Water Piping: [0 to 200 psi (0 to 1400 kPa)] **[0 to 200 psi and 0 to 1400 kPa]**.
- M. Scale Range for Condenser-Water Piping: [0 to 300 psi (0 to 2500 kPa)] **[0 to 300 psi and 0 to 2500 kPa]**.
- N. Scale Range for Condenser-Water Piping: [0 to 600 psi (0 to 4000 kPa)] **[0 to 600 psi and 0 to 4000 kPa]**.

- O. Scale Range for Heating, Hot-Water Piping: [30-in. Hg to 15 psi (minus 100 to 0 kPa)] [**30-in. Hg to 15 psi and minus 100 to 0 kPa**].
 - P. Scale Range for Heating, Hot-Water Piping: [0 to 30 psi (0 to 240 kPa)] [**0 to 30 psi and 0 to 240 kPa**].
 - Q. Scale Range for Heating, Hot-Water Piping: [0 to 100 psi (0 to 600 kPa)] [**0 to 100 psi and 0 to 600 kPa**].
 - R. Scale Range for Heating, Hot-Water Piping: [0 to 160 psi (0 to 1100 kPa)] [**0 to 160 psi and 0 to 1100 kPa**].
 - S. Scale Range for Heating, Hot-Water Piping: [0 to 200 psi (0 to 1400 kPa)] [**0 to 200 psi and 0 to 1400 kPa**].
 - T. Scale Range for Heating, Hot-Water Piping: [0 to 300 psi (0 to 2500 kPa)] [**0 to 300 psi and 0 to 2500 kPa**].
 - U. Scale Range for Heating, Hot-Water Piping: [0 to 600 psi (0 to 4000 kPa)] [**0 to 600 psi and 0 to 4000 kPa**].
 - V. Scale Range for Steam Piping: [30-in. Hg to 15 psi (minus 100 to 0 kPa)] [**30-in. Hg to 15 psi and minus 100 to 0 kPa**].
 - W. Scale Range for Steam Piping: [0 to 30 psi (0 to 240 kPa)] [**0 to 30 psi and 0 to 240 kPa**].
 - X. Scale Range for Steam Piping: [0 to 100 psi (0 to 600 kPa)] [**0 to 100 psi and 0 to 600 kPa**].
 - Y. Scale Range for Steam Piping: [0 to 160 psi (0 to 1100 kPa)] [**0 to 160 psi and 0 to 1100 kPa**].
 - Z. Scale Range for Steam Piping: [0 to 200 psi (0 to 1400 kPa)] [**0 to 200 psi and 0 to 1400 kPa**].
 - AA. Scale Range for Steam Piping: [0 to 300 psi (0 to 2500 kPa)] [**0 to 300 psi and 0 to 2500 kPa**].
 - BB. Scale Range for Steam Piping: [0 to 600 psi (0 to 4000 kPa)] [**0 to 600 psi and 0 to 4000 kPa**].
- 3.8 FLOWMETER SCHEDULE
- A. Flowmeters for Chilled-Water Piping: [**Orifice**] [**Pitot-tube**] [**Turbine**] [**Venturi**] [**Vortex-shedding**] type.
 - B. Flowmeters for Condenser-Water Piping: [**Orifice**] [**Pitot-tube**] [**Turbine**] [**Venturi**] [**Vortex-shedding**] type.
 - C. Flowmeters for Heating, Hot-Water Piping: [**Orifice**] [**Pitot-tube**] [**Turbine**] [**Venturi**] [**Vortex-shedding**] type.
 - D. Flowmeters for Steam and Steam-Condensate Piping: [**Orifice**] [**Turbine**] [**Venturi**] [**Vortex-shedding**] type.

3.9 THERMAL-ENERGY METER SCHEDULE

- A. Thermal-Energy Meters for Chilled-Water Piping: [**Impeller-turbine**] [**Ultrasonic**] type.
- B. Thermal-Energy Meters for Condenser-Water Piping: [**Impeller-turbine**] [**Ultrasonic**] type.
- C. Thermal-Energy Meters for Heating, Hot-Water Piping: [**Impeller-turbine**] [**Ultrasonic**] type.
- D. Thermal-Energy Meters for Steam and Steam-Condensate Piping: [**Impeller-turbine**] [**Ultrasonic**] type.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 0523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Globe valves.
 - 2. Ball valves.
 - 3. Butterfly valves.
 - 4. Check valves.
 - 5. Gate valves.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene-diene monomer.
- C. FKM: Fluoroelastomer.
- D. NBR: Nitrile butadiene rubber (also known as "Buna-N").
- E. NRS: Nonrising stem.
- F. OS&Y: Outside screw and yoke.
- G. PTFE: Polytetrafluoroethylene.
- H. RPTFE: Reinforced polytetrafluoroethylene.
- I. RS: Rising stem.
- J. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions and dimensions of individual components.
 - 2. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. Set butterfly valves closed or slightly open.
 - 5. Block check valves in either closed or open position.
 - 6. Set gate valves closed to prevent rattling.
 - 7. Set plug valves to open to minimize exposure of functional surfaces.

- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 5. ASME B16.18 for cast-copper solder-joint connections.
 - 6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
 - 7. ASME B16.34 for flanged- and threaded-end connections.
 - 8. ASME B16.51 for press joint connections.
 - 9. ASME B31.1 for power piping valves.
 - 10. ASME B31.9 for building services piping valves.
- B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Bypass and Drain Connections: MSS SP-45.
- G. Valve Actuator Type:
 - 1. Gear Actuator: For quarter-turn ball valves NPS 4 (DN 100) and larger.
 - 2. Hand Lever: For quarter-turn ball valves smaller than NPS 4 (DN 100).
- H. Valves in Insulated Piping:
 - 1. Provide 2-inch (50-mm) extended neck stems.
 - 2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.

3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 GLOBE VALVES

A. Globe Valves, Flanged Ends - Iron, Class 250:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Crane Fluid Systems; Crane Co.
 - c. Hammond Valve.
 - d. Jenkins Valves; a Crane Co. brand.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Siemens Industry, Inc., Building Technologies Division.
 - h. Stockham; a Crane Co. brand.
2. Standard: MSS SP-85, Type I.
3. CWP Rating: 500 psig (3450 kPa).
4. Body Material: ASTM A126, gray iron with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Packing and Gasket: Asbestos free.
8. Operator: Handwheel or chainwheel.

2.4 BALL VALVES

A. Ball Valves, Threaded or Soldered Ends - Brass, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Crane Fluid Systems; Crane Co.
 - d. Flow-Tek; a subsidiary of Bray International.
 - e. Hammond Valve.
 - f. Milwaukee Valve Company.
 - g. Siemens Industry, Inc., Building Technologies Division.
 - h. Stockham; a Crane Co. brand.
 - i. Viega LLC.
 - j. WATTS; A Watts Water Technologies Company.
2. Standard: MSS SP-110.
3. SWP Rating: 150 psig (1035 kPa).
4. CWP Rating: 600 psig (4140 kPa).
5. Body Design: Two piece.
6. Body Material: Forged brass.
7. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
8. Seats: PTFE.
9. Stem: Stainless steel.
10. Ball: Stainless steel, vented.
11. Port: Full.

B. Ball Valves, Threaded or Soldered Ends - Bronze, Two Piece with Full Port and Stainless Steel Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Crane Fluid Systems; Crane Co.
 - c. DynaQuip Controls.
 - d. Hammond Valve.
 - e. Jenkins Valves; a Crane Co. brand.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Red-White Valve Corp.
 - i. Stockham; a Crane Co. brand.
 - j. Viega LLC.
 - k. WATTS; A Watts Water Technologies Company.
2. Standard: MSS SP-110.
3. SWP Rating: 150 psig (1035 kPa).
4. CWP Rating: 600 psig (4140 kPa).
5. Body Design: Two piece.
6. Body Material: Bronze.
7. Ends: Threaded or soldered. See Part 3 ball valve schedule articles.
8. Seats: PTFE.
9. Stem: Stainless steel.
10. Ball: Stainless steel, vented.
11. Port: Full.

C. Ball Valves, Threaded or Flanged Ends - Stainless Steel, Two Piece with Full Port:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Bray International, Inc.
 - d. FNW; Ferguson Enterprises, Inc.
 - e. Hammond Valve.
 - f. Jomar Valve.
2. Standard: MSS SP-110.
3. SWP Rating: 150 psig (1030 kPa).
4. WOG Rating: 1000 psig (6895 kPa).
5. Body Design: Split body.
6. Body Material: Type 316 stainless steel.
7. Ends: Threaded or flanged. See Part 3 ball valve schedule articles.
8. Seats: PTFE.
9. Stem: Type 316 stainless steel.
10. Ball: Type 316 stainless steel.
11. Port: Full.

2.5 BUTTERFLY VALVES

A. Butterfly Valves, Single Flange (Lug Type) - High Performance, Class 300:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABZ Valve; an ASC Engineered Solution.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Bray International, Inc.
 - d. DeZURIK.
 - e. Flowseal; Crane Energy Flow Solutions.
 - f. Hammond Valve.
 - g. Jamesbury; a brand of Valmet.
 - h. Milwaukee Valve Company.
 - i. NIBCO INC.
 - j. Process Development & Control, Inc.
 - k. Stockham; a Crane Co. brand.
 - l. XOMOX; Crane ChemPharma & Energy.
2. Standard: MSS SP-68.
3. CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).
4. Body Design: Single flange (lug type), suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
5. Body Material: Carbon or stainless steel. See Part 3 butterfly valve schedule articles.
6. Seat: Reinforced PTFE or metal.
7. Stem: Stainless steel; offset from seat plane.
8. Disc: Type 316 stainless steel.
9. Service: Bidirectional.

2.6 CHECK VALVES

- A. Check Valves, Swing Type, Threaded Ends - Bronze, with Bronze Disc, Class 150:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Crane Fluid Systems; Crane Co.
 - d. Hammond Valve.
 - e. Jenkins Valves; a Crane Co. brand.
 - f. Lance Valves.
 - g. Milwaukee Valve Company.
 - h. NIBCO INC.
 - i. Powell Valves.
 - j. Stockham; a Crane Co. brand.
 2. Standard: MSS SP-80, Type 3.
 3. CWP Rating: 300 psig (2070 kPa).
 4. Body Design: Horizontal flow.
 5. Body Material: ASTM B62, bronze.
 6. Ends: Threaded.
 7. Disc: Bronze.
- B. Check Valves, Swing Type, Flanged Ends - Iron, with Metal Seats, Class 250:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bray International, Inc.

- c. Cooper Valves.
- d. Crane Fluid Systems; Crane Co.
- e. Crispin Valve.
- f. DeZURIK.
- g. FNW; Ferguson Enterprises, Inc.
- h. GA Industries, Inc.
- i. Hammond Valve.
- j. Jenkins Valves; a Crane Co. brand.
- k. KITZ Corporation.
- l. Lance Valves.
- m. Milwaukee Valve Company.
- n. Powell Valves.
- o. Victaulic Company.
- 2. Standard: MSS SP-71, Type I.
- 3. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 500 psig (3450 kPa).
- 4. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): 300 psig (2070 kPa).
- 5. Body Design: Clear or full waterway.
- 6. Body Material: ASTM A126, gray iron with bolted bonnet.
- 7. Ends: Flanged.
- 8. Trim: Bronze.
- 9. Gasket: Asbestos free.

2.7 GATE VALVES

- A. Gate Valves, Threaded Ends - Bronze, NRS, Class 150:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Crane Fluid Systems; Crane Co.
 - d. Jenkins Valves; a Crane Co. brand.
 - e. Milwaukee Valve Company.
 - f. Stockham; a Crane Co. brand.
 - g. WATTS; A Watts Water Technologies Company.
 - 2. Standard: MSS SP-80, Type 1.
 - 3. CWP Rating: 300 psig (2070 kPa).
 - 4. Body Material: ASTM B62, bronze with integral seat and union-ring bonnet.
 - 5. Ends: Threaded.
 - 6. Stem: Bronze.
 - 7. Disc: Solid wedge, bronze.
 - 8. Packing: Asbestos free.
 - 9. Handwheel: Malleable iron, bronze, or aluminum.
- B. Gate Valves, Flanged Ends - Iron, NRS, Class 250:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Clow Valve Company; a subsidiary of McWane, Inc.
 - c. Cooper Valves.
 - d. Crane Fluid Systems; Crane Co.
 - e. Flomatic Valves; Flomatic Corporation.

- f. FNW; Ferguson Enterprises, Inc.
- g. Jenkins Valves; a Crane Co. brand.
- h. KITZ Corporation.
- i. Victaulic Company.
- j. Zurn Industries, LLC.
- 2. Standard: MSS SP-70, Type I.
- 3. CWP Rating, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): 500 psig (3450 kPa).
- 4. CWP Rating, NPS 14 to NPS 24 (DN 350 to DN 600): 300 psig (2070 kPa).
- 5. Body Material: ASTM A126, gray iron with bolted bonnet.
- 6. Ends: Flanged.
- 7. Trim: Bronze.
- 8. Disc: Solid wedge.
- 9. Packing and Gasket: Asbestos free.

2.8 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Babbitt Steam Specialty Co.
 - 2. Roto Hammer Industries; Rotork.
 - 3. Trumbull Industries.
- B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.
 - 1. Sprocket Rim with Chain Guides: Bronze, of type and size required for valve. Include zinc or epoxy coating.
 - 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Examine press fittings to verify they have been properly pressed.
- F. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.
- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
- H. Chainwheels: Install chainwheels on manual operators for globe butterfly gate valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
- I. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves, Swing Type: In horizontal position with hinge pin level.
- J. Valve Tags: Comply with requirements for valve tags and schedules in Section 23 0553 "Identification for HVAC Piping and Equipment."
- K. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End Copper Tubing, except Steam and Steam Condensate Piping: Valve ends may be grooved.
8. For Grooved-End Steel Piping, except Steam and Steam Condensate Piping: Valve ends may be grooved.
9. Wafer-Type Valves: Flanged connections.

3.5 CHILLED-WATER ANGLE OR GLOBE VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Globe valves, threaded ends - bronze, Class 150; stainless steel disc.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Globe valves, flanged ends - iron, Class 250.

3.6 HEATING-WATER ANGLE OR GLOBE VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Globe valves, threaded ends - bronze, Class 150; stainless steel disc.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Globe valves, flanged ends - iron, Class 250.

3.7 LOW-PRESSURE STEAM ANGLE OR GLOBE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Globe valves, threaded ends - bronze, Class 150; stainless steel disc.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Globe valves, flanged ends - iron, Class 250.

3.8 CHILLED-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim, threaded soldered ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.9 COOLING-COIL CONDENSATE BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 1. Ball valves, threaded or soldered ends - brass, two piece with full port and brass trim; threaded soldered ends.
 2. Ball valves, threaded or soldered ends - bronze, two piece with full port and bronze or brass trim; threaded soldered ends.

3.10 HEATING-WATER BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Ball valves, threaded or soldered ends - brass, two piece with full port and stainless steel trim; threaded soldered ends.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Ball valves, flanged ends - steel, with full port and stainless steel trim, Class 300.

3.11 LOW-PRESSURE CLEAN STEAM BALL VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

- A. Pipe NPS 2 (DN 50) and Smaller: Ball valves, threaded ends - stainless steel, two piece with full port.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Ball valves, flanged ends - stainless steel, two piece with full port.

3.12 CLEAN STEAM-CONDENSATE BALL VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller: Ball valves, threaded ends - stainless steel, two piece with full port.
- B. Pipe NPS 2-1/2 (DN 65) and Larger: Ball valves, flanged ends - stainless steel, two piece with full port.

3.13 CHILLED-WATER BUTTERFLY VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
 - 7. Butterfly valves, grooved end - ductile iron, 175 CWP.
 - 8. Butterfly valves, grooved end - ductile iron, 300 CWP.
 - 9. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
 - 10. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.14 CONDENSER-WATER BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
7. Butterfly valves, grooved end - ductile iron, 175 CWP.
8. Butterfly valves, grooved end - ductile iron, 300 CWP.
9. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
10. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.15 HEATING-WATER BUTTERFLY VALVE SCHEDULE

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
2. Butterfly valves, single flange (lug type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
3. Butterfly valves, single flange (lug type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
4. Butterfly valves, flangeless (wafer type) - iron, with aluminum-bronze disc; [150] [200] CWP, [EPDM] [NBR] seat.
5. Butterfly valves, flangeless (wafer type) - iron, with ductile-iron disc; [150] [200] CWP, [EPDM] [NBR] seat.
6. Butterfly valves, flangeless (wafer type) - iron, with stainless steel disc; [150] [200] CWP, [EPDM] [NBR] seat.
7. Butterfly valves, grooved end - ductile iron, 175 CWP.
8. Butterfly valves, grooved end - ductile iron, 300 CWP.
9. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
10. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.

3.16 LOW-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.

2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.
- 3.17 LOW-PRESSURE CLEAN STEAM BUTTERFLY VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
 2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.
- 3.18 HIGH-PRESSURE STEAM BUTTERFLY VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high-performance, Class 150 stainless steel body.
 2. Butterfly valves, single flange (lug type) - high-performance, Class 300 stainless steel body.
- 3.19 HIGH-PRESSURE CLEAN STEAM BUTTERFLY VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
 2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.
- 3.20 STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
 2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.
- 3.21 CLEAN-STEAM-CONDENSATE BUTTERFLY VALVE SCHEDULE
- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Butterfly valves, single flange (lug type) - high performance, Class 150; stainless steel body.
 2. Butterfly valves, single flange (lug type) - high performance, Class 300; stainless steel body.
- 3.22 CHILLED-WATER CHECK VALVE SCHEDULE
- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.

3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
 7. Check valves, swing type, press ends - bronze.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
 4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
 5. Check valves, center guided - iron, globe, with metal seat, Class 125.
 6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 7. Check valves, center guided - iron, globe, with metal seat, Class 150.
 8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 9. Check valves, center guided - iron, globe, with metal seat, Class 250.
 10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 11. Check valves, center guided - iron, globe, with metal seat, Class 300.
 12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR].
 13. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR].
 14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR].
 15. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR].
 16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR].
 17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR].
 18. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM] [NBR].
 19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR].
 20. Check valves, dual-plate type - iron, with metal seat, Class 125.
 21. Check valves, dual-plate type - iron, with metal seat, Class 150.
 22. Check valves, dual-plate type - iron, with metal seat, Class 250.
 23. Check valves, dual-plate type - iron, with metal seat, Class 300.
 24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
 25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
 26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM] [NBR] seat.
 27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
 28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
 29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM] [NBR] seat.
- C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):

1. Check valves, swing type, grooved ends - iron, 300 CWP.

E. For CPVC Pipe:

1. CPVC Union-Type Ball Check Valve: [NPS 2 (DN 50) and smaller] [NPS 4 (DN 100) and smaller] [125 psig (860 kPa)] [150 psig (1035 kPa)] <Insert pressure> at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: Socket Socket or threaded Threaded Flanged.

F. For PVC Pipe:

1. PVC Union-Type Ball Check Valve: NPS 4 (DN 100) at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket Socket or threaded Threaded Flanged.

3.23 CONDENSER-WATER CHECK VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.
3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
7. Check valves, swing type, press ends - bronze.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
5. Check valves, center guided - iron, globe, with metal seat, Class 125.
6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
7. Check valves, center guided - iron, globe, with metal seat, Class 150.
8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
9. Check valves, center guided - iron, globe, with metal seat, Class 250.
10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
11. Check valves, center guided - iron, globe, with metal seat, Class 300.
12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR].
13. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR].
14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR].
15. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR].
16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR].
17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR].

18. Check valves, center guided - iron, compact water, with resilient seat, Class 300; [EPDM] [NBR].
 19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR].
 20. Check valves, dual-plate type - iron, with metal seat, Class 125.
 21. Check valves, dual-plate type - iron, with metal seat, Class 150.
 22. Check valves, dual-plate type - iron, with metal seat, Class 250.
 23. Check valves, dual-plate type - iron, with metal seat, Class 300.
 24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
 25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
 26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM] [NBR] seat.
 27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
 28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
 29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM] [NBR] seat.
- C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
1. Check valves, swing type, grooved ends - iron, 300 CWP.
- E. For CPVC Pipe:
1. CPVC Union-Type Ball Check Valve: [NPS 2 (DN 50) and smaller] [NPS 4 (DN 100) and smaller] [125 psig (860 kPa)] [150 psig (1035 kPa)] <Insert pressure> at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: Socket Socket or threaded Threaded Flanged.
- F. For PVC Pipe:
1. PVC Union-Type Ball Check Valve: NPS 4 (DN 100) at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket Socket or threaded Threaded Flanged.
- 3.24 HEATING-WATER CHECK VALVE SCHEDULE
- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, lift type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, lift type, threaded ends - bronze, with nonmetallic disc, Class 125.
 3. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 4. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 5. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 6. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
 7. Check valves, swing type, press ends - bronze.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
4. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
5. Check valves, center guided - iron, globe, with metal seat, Class 125.
6. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
7. Check valves, center guided - iron, globe, with metal seat, Class 150.
8. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
9. Check valves, center guided - iron, globe, with metal seat, Class 250.
10. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
11. Check valves, center guided - iron, globe, with metal seat, Class 300.
12. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR].
13. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR].
14. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR].
15. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR].
16. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR].
17. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR].
18. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM] [NBR].
19. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR].
20. Check valves, dual-plate type - iron, with metal seat, Class 125.
21. Check valves, dual-plate type - iron, with metal seat, Class 150.
22. Check valves, dual-plate type - iron, with metal seat, Class 250.
23. Check valves, dual-plate type - iron, with metal seat, Class 300.
24. Check valves, single-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
25. Check valves, dual-plate type - iron, with resilient seat, Class 125; [EPDM] [NBR] seat.
26. Check valves, dual-plate type - iron, with resilient seat, Class 150; [EPDM] [NBR] seat.
27. Check valves, single-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
28. Check valves, dual-plate type - iron, with resilient seat, Class 250; [EPDM] [NBR] seat.
29. Check valves, dual-plate type - iron, with resilient seat, Class 300; [EPDM] [NBR] seat.

C. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):

1. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
2. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

D. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):

1. Check valves, swing type, grooved ends - iron, 300 CWP.

3.25 LOW-PRESSURE STEAM CHECK VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:

1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
 4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- 3.26 HIGH-PRESSURE STEAM CHECK VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)
- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
 4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- 3.27 STEAM-CONDENSATE CHECK VALVE SCHEDULE
- A. Pipe NPS 2 (DN 50) and Smaller:
1. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 2. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 3. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Check valves, swing type, flanged ends - iron, with metal seats, Class 125.
 2. Check valves, swing type, flanged ends - iron, with nonmetallic-to-metal seats, Class 125.
 3. Check valves, swing type, flanged ends - iron, with metal seats, Class 250.
 4. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 5. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.28 PUMP-DISCHARGE CHECK VALVE SCHEDULE

A. Chilled-Water Pump Discharge:

1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 - b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 150.
2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 - c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
 - d. Check valves, center guided - iron, globe, with metal seat, Class 125.
 - e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 - f. Check valves, center guided - iron, globe, with metal seat, Class 150.
 - g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 - h. Check valves, center guided - iron, globe, with metal seat, Class 250.
 - i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 - j. Check valves, center guided - iron, globe, with metal seat, Class 300.
 - k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR] seat.
 - l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR] seat.
 - m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR] seat.
 - n. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR] seat.
 - o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR] seat.
 - p. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR] seat.
 - q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM] [NBR] seat.
 - r. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR] seat.
3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
 - a. Check valves, swing type, grooved ends - iron, 300 CWP.

B. Condenser-Water Pump Discharge:

1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.

- b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded or soldered ends - bronze, with nonmetallic disc, Class 150.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
 - c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
 - d. Check valves, center guided - iron, globe, with metal seat, Class 125.
 - e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
 - f. Check valves, center guided - iron, globe, with metal seat, Class 150.
 - g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
 - h. Check valves, center guided - iron, globe, with metal seat, Class 250.
 - i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
 - j. Check valves, center guided - iron, globe, with metal seat, Class 300.
 - k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR] seat.
 - l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR] seat.
 - m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR] seat.
 - n. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR] seat.
 - o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR] seat.
 - p. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR] seat.
 - q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM] [NBR] seat.
 - r. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR] seat.
 - 3. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
 - a. Check valves, swing type, grooved-end - iron, 300 CWP.
- C. Heating-Water Pump Discharge:
 - 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 - b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded or soldered ends - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded or soldered ends - bronze, with nonmetallic disc, Class 150.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger:
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.

- b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- c. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 125.
- d. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 125.
- e. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 150.
- f. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 150.
- g. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 250.
- h. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 250.
- i. Check valves, center guided - iron, spring loaded, compact wafer, with metal seat, Class 300.
- j. Check valves, center guided - iron, spring loaded, globe, with metal seat, Class 300.
- k. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 125; **[EPDM]** **[NBR]** seat.
- l. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 125; **[EPDM]** **[NBR]** seat.
- m. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 150; **[EPDM]** **[NBR]** seat.
- n. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 150; **[EPDM]** **[NBR]** seat.
- o. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 250; **[EPDM]** **[NBR]** seat.
- p. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 250; **[EPDM]** **[NBR]** seat.
- q. Check valves, center guided - iron, spring loaded, compact wafer, with resilient seat, Class 300; **[EPDM]** **[NBR]** seat.
- r. Check valves, center guided - iron, spring loaded, globe, with resilient seat, Class 300; **[EPDM]** **[NBR]** seat.
- 3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300):
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- 4. Pipe NPS 3 to NPS 12 (DN 80 to DN 300):
 - a. Check valves, swing type, grooved ends - iron, 300 CWP.
- D. Steam-Condensate Pump Discharge:
 - 1. Pipe NPS 2 (DN 50) and Smaller:
 - a. Check valves, swing type, threaded ends - bronze, with bronze disc, Class 125.
 - b. Check valves, swing type, threaded ends - bronze, with nonmetallic disc, Class 125.
 - c. Check valves, swing type, threaded - bronze, with bronze disc, Class 150.
 - d. Check valves, swing type, threaded - bronze, with nonmetallic disc, Class 150.
 - 2. Pipe NPS 2-1/2 (DN 65) and Larger for Steam Condensate Pumps:

- a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
- b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.
- c. Check valves, center guided - iron, compact wafer, with metal seat, Class 125.
- d. Check valves, center guided - iron, globe, with metal seat, Class 125.
- e. Check valves, center guided - iron, compact wafer, with metal seat, Class 150.
- f. Check valves, center guided - iron, globe, with metal seat, Class 150.
- g. Check valves, center guided - iron, compact wafer, with metal seat, Class 250.
- h. Check valves, center guided - iron, globe, with metal seat, Class 250.
- i. Check valves, center guided - iron, compact wafer, with metal seat, Class 300.
- j. Check valves, center guided - iron, globe, with metal seat, Class 300.
- k. Check valves, center guided - iron, compact wafer, with resilient seat, Class 125; [EPDM] [NBR] seat.
- l. Check valves, center guided - iron, globe, with resilient seat, Class 125; [EPDM] [NBR] seat.
- m. Check valves, center guided - iron, compact wafer, with resilient seat, Class 150; [EPDM] [NBR] seat.
- n. Check valves, center guided - iron, globe, with resilient seat, Class 150; [EPDM] [NBR] seat.
- o. Check valves, center guided - iron, compact wafer, with resilient seat, Class 250; [EPDM] [NBR] seat.
- p. Check valves, center guided - iron, globe, with resilient seat, Class 250; [EPDM] [NBR] seat.
- q. Check valves, center guided - iron, compact wafer, with resilient seat, Class 300; [EPDM] [NBR] seat.
- r. Check valves, center guided - iron, globe, with resilient seat, Class 300; [EPDM] [NBR] seat.
- 3. Pipe NPS 2-1/2 to NPS 12 (DN 65 to DN 300) for Steam Condensate Pumps:
 - a. Check valves, swing type, flanged ends - iron, with lever- and spring-closure control, Class 125.
 - b. Check valves, swing type, flanged ends - iron, with lever- and weight-closure control, Class 125.

3.29 CHILLED-WATER GATE VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded soldered ends.
 - 2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded soldered ends.
 - 3. Gate valves, threaded ends - bronze, NRS, Class 150.
 - 4. Gate valves, threaded ends - bronze, RS, Class 150.
 - 5. Gate valves, press ends - bronze; [RS] [NRS].
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
 - 1. Gate valves, flanged ends - iron, NRS, Class 125.
 - 2. Gate valves, flanged ends - iron, OS&Y, Class 125.
 - 3. Gate valves, flanged ends - iron, NRS, Class 250.
 - 4. Gate valves, flanged ends - iron, OS&Y, Class 250.
- C. CPVC Pipe:

1. CPVC Gate Valve: [NPS 2 (DN 50) and smaller] [NPS 4 (DN 100) and smaller] [125 psig (860 kPa)] [150 psig (1035 kPa)] <Insert pressure> at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: Socket Socket or threaded Threaded Flanged.

D. PVC Pipe:

1. PVC Gate Valve: NPS 4 (DN 100) at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket Socket or threaded Threaded Flanged.

3.30 CONDENSER-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded soldered ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded soldered ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.
5. Gate valves, press ends - bronze; [RS] [NRS].

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

C. CPVC Pipe:

1. CPVC Gate Valve: [NPS 2 (DN 50) and smaller] [NPS 4 (DN 100) and smaller] [125 psig (860 kPa)] [150 psig (1035 kPa)] <Insert pressure> at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100) and Larger: Socket Socket or threaded Threaded Flanged.

D. PVC Pipe:

1. PVC Gate Valve: NPS 4 (DN 100) at [73 deg F (23 deg C)] <Insert temperature>.
 - a. End Connections for Valves NPS 2 (DN 50) and Smaller: Socket or threaded.
 - b. End Connections for Valves NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Socket Socket or threaded Threaded Flanged.

3.31 HEATING-WATER GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded soldered ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded soldered ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.
5. Gate valves, press ends - bronze; [RS] [NRS].

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.32 LOW-PRESSURE STEAM GATE VALVE SCHEDULE - 15 PSIG (104 kPa) OR LESS

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.33 HIGH-PRESSURE STEAM GATE VALVE SCHEDULE - MORE THAN 15 PSIG (104 kPa)

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.34 STEAM-CONDENSATE GATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Gate valves, threaded or soldered ends - bronze, NRS, Class 125; threaded ends.
2. Gate valves, threaded or soldered ends - bronze, RS, Class 125; threaded ends.
3. Gate valves, threaded ends - bronze, NRS, Class 150.
4. Gate valves, threaded ends - bronze, RS, Class 150.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Gate valves, flanged ends - iron, NRS, Class 125.
2. Gate valves, flanged ends - iron, OS&Y, Class 125.
3. Gate valves, flanged ends - iron, NRS, Class 250.
4. Gate valves, flanged ends - iron, OS&Y, Class 250.

3.35 CHILLED-WATER PLUG VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Plug valves, lubricated type, threaded ends - Class 125.
 2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland]** [or] **[Type II regular gland]**.
 3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
 4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
 5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
 8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
 9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.36 CONDENSER-WATER PLUG VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Plug valves, lubricated type, threaded ends - Class 125.
 2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland]** [or] **[Type II regular gland]**.
 3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
 4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
 5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
 8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
 9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.37 HEATING-WATER PLUG VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Plug valves, lubricated type, threaded ends - Class 125.
 2. Plug valves, lubricated type, flanged ends - Class 125; **[Type I single gland]** [or] **[Type II regular gland]**.
 3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
 4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
 5. Plug valves, lubricated type, threaded ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 6. Plug valves, lubricated type, flanged ends - Class 250; **[Type I single gland]** [or] **[Type II regular gland]**.
 7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
 8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
 9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

3.38 STEAM-CONDENSATE PLUG VALVE SCHEDULE

- A. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Plug valves, lubricated type, threaded ends - Class 125.
 2. Plug valves, lubricated type, flanged ends - Class 125; [**Type I single gland**] [or] [**Type II regular gland**].
 3. Plug valves, lubricated type, threaded ends - cylindrical, Class 125.
 4. Plug valves, lubricated type, flanged ends - cylindrical, Class 125.
 5. Plug valves, lubricated type, threaded ends - Class 250; [**Type I single gland**] [or] [**Type II regular gland**].
 6. Plug valves, lubricated type, flanged ends - Class 250; [**Type I single gland**] [or] [**Type II regular gland**].
 7. Plug valves, lubricated type, threaded ends - cylindrical, Class 250.
 8. Plug valves, lubricated type, flanged ends - cylindrical, Class 250.
 9. Plug valves, eccentric type, flanged ends - with resilient seat, 175 CWP.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Pipe stands.
7. Equipment stands.
8. Equipment supports.

B. Related Requirements:

1. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 23 0500 "Common Work Results for HVAC" for pipe guides and anchors.
3. Section 23 0548.13 "Vibration Controls for HVAC" for vibration isolation devices.
4. Section 23 3116 "Nonmetal Ducts" for duct hangers and supports.
5. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product. Include dimensions and methods of assembly and attachment to building structure.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Pipe stands.
4. Equipment supports.

C. Delegated Design Submittals: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers. Show dimensions and methods of assembly and attachment to building structure.
2. Include design calculations for designing trapeze hangers.
3. Include Piping layout, trapeze hanger layout, pipe stand layout, metal framing system layout, equipment stand layout, equipment support layout, drawn to scale, indicating the items described in this Section, and coordinated with all building trades. Show dimensions and methods of assembly and attachment to building structure for each trapeze hanger, pipe stand, metal framing system, equipment stand and equipment support..

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 - 3. Limit point loads on new building structural systems to no less than [6'] on center along the length of a structural beam and [500 lbs] of combined weight of supported systems, system contents, and test water.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated, or epoxy powder-coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. Flex-Strut Inc.
 - d. G-Strut.
 - e. Haydon Corporation.
 - f. MIRO Industries.
 - g. Rooftop Support Systems; Eberl Iron Works, Inc.
 - h. Unistrut; Atkore International.
 - i. Wesanco, Inc.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted stainless steel, Type 304 channel with inturred lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
8. Paint Coating: Green epoxy, acrylic, or urethane.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 - b. CADDY; brand of nVent Electrical plc.
 - c. Carpenter & Paterson, Inc.
 - d. Empire Industries, Inc.
 - e. Gripple Inc.
 - f. MIRO Industries.
 - g. PHD Manufacturing, Inc.
 - h. RectorSeal HVAC; a CSW Industrials Company.
2. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
4. Channels: Continuous slotted stainless steel channel with inturred lips.
5. Channel Width: Select for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel.
8. Metallic Coating: No coating.

9. Paint Coating: Green epoxy, acrylic, or urethane Insert paint coating.
10. Plastic Coating: PVC Insert plastic type.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Buckaroos, Inc.
 2. CADDY; brand of nVent Electrical plc.
 3. Carpenter & Paterson, Inc.
 4. KB Enterprise.
 5. National Pipe Hanger Corporation.
 6. Pipe Shields Inc.
 7. Piping Technology & Products, Inc.
 8. Rilco Manufacturing Co., Inc.
 9. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi (862-kPa) minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi (688-kPa) or ASTM C552, Type II cellular glass with 100-psi (688-kPa) or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi (862-kPa) minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector.
 - b. Empire Industries, Inc.

- c. Hilti, Inc.
- d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
- e. MKT Fastening, LLC.
- 2. Indoor Applications: stainless steel.
- 3. Outdoor Applications: Stainless steel.

2.7 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries.
 - b. PHP Systems/Design.
 - c. RectorSeal HVAC; a CSW Industrials Company.
 - 2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 4. Hardware: Galvanized steel or polycarbonate.
 - 5. Accessories: Protection pads.
- C. Low-Profile, Single Base, Single-Pipe Stand:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries.
 - b. PHP Systems/Design.
 - 2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
 - 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 4. Vertical Members: Two, galvanized- steel, continuous-thread 1/2-inch (12-mm) rods.
 - 5. Horizontal Member: Adjustable horizontal, galvanized- steel pipe support channels.
 - 6. Pipe Supports: Roller Strut clamps Clevis hanger Swivel hanger.
 - 7. Hardware: Galvanized steel.
 - 8. Accessories: Protection pads.
 - 9. Height: 12 inches (300 mm) above roof.
- D. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.9 OUTDOOR EQUIPMENT STANDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. MIRO Industries.
 2. RectorSeal HVAC; a CSW Industrials Company.
- B. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.
- C. Foot Material: Rubber or polypropylene.
- D. Rails Material: Hot dip galvanized carbon steel.
- E. Wind/Sliding Load Resistance: Up to 100 mph (44 mps) minimum.
- 2.10 MATERIALS
- A. Aluminum: ASTM B221 (ASTM B221M).
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
- F. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Framing System Installation: Metal. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 07 7200 "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- N. Insulated Piping:
1. Attach clamps and spacers to piping.

- a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
- b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
- c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Thermal-hanger shield inserts may be used as an option. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 INSTALLATION OF EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

- A. Touchup:
 1. Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
 2. Comply with requirements in Section 09 9113 "Exterior Painting" Section 09 9123 "Interior Painting" and Section 09 9600 "High-Performance Coatings" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
 3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal framing systems and attachments for general service applications.
- F. Use stainless steel pipe hangers and stainless steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and stainless steel attachments for copper piping and tubing.

- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
 8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 23 0548.13 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Air-spring isolators.
11. Restrained-air-spring isolators.
12. Elastomeric hangers.
13. Spring hangers.
14. Snubbers.
15. Restraints - rigid type.
16. Restraints - cable type.
17. Restraint accessories.
18. Post-installed concrete anchors.
19. Concrete inserts.
20. Vibration isolation equipment bases.
21. Restrained isolation roof-curb rails.

B. Related Requirements:

1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
2. Section 21 0548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
3. Section 22 0548.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing equipment and systems.

1.2 DEFINITIONS

A. IBC: International Building Code.

B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Include load rating for each wind-force-restraint fitting and assembly.

3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
 4. Annotate to indicate application of each product submitted and compliance with requirements.
 5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases.
 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints.
- B. Qualification Data: For testing agency.
- C. Welding certificates.
- D. Air-Spring Mounting System Performance Certification: Include natural frequency, load, and damping test data.
- E. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.
- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design system.
 1. Material properties indicated in this Section shall be considered as minimum properties.
- B. Suspended piping:

1. Spring Hangers or Rubber Hangers shall be used for all piping in equipment rooms and up to 50 ft from vibration isolated equipment and pressure regulating valve (PRV) stations.
 - a. The first three hangers from the equipment shall provide the same deflection as the equipment isolators, with a maximum limitation of 2 in. deflection.
 - b. The remaining hangers shall be spring or combination spring and rubber with 0.75 in. deflection.
 2. The first two hangers adjacent to the equipment shall be the positioning of precompressed type, to prevent load transfer to equipment flanges when the piping system is filled.
 3. Piping over 2 in. in diameter that is suspended below or within 50 ft of noise-sensitive areas shall be hung with combination spring and rubber hangers.
 - a. Animal Holding Spaces (All three (3) dens, Quarantine and Cubbing Spaces)
 - b. Adjacent Corridors to dens and Quarantine and cubbing spaces.
 - c. Day Room
- C. Floor-supported piping:
1. Floor supports for piping in equipment rooms and adjacent to isolated equipment shall use vibration isolators as described in Table 47, Chapter 49 of ASHRAE Handbook - HVAC Applications.
 - a. The first two adjacent floor supports shall be the restrained spring type, with a blocking feature that prevents load transfer to equipment flanges as the piping is filled or drained.
 2. Where the piping is subjected to large thermal movement, a slide plate (PTFE, graphite or steel) shall be installed on top of the isolator and a thermal barrier shall be used when rubber products are installed directly beneath steam or hot-water lines.
- D. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- E. Component Supports:
1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
- ## 2.2 ELASTOMERIC ISOLATION PADS
- A. Elastomeric Isolation Pads: .
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Novia; A Division of C&P.
 - i. Vibration Eliminator Co., Inc.
 - j. Vibration Management Corp.
 - k. Vibration Mountings & Controls, Inc.
 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.

3. Size: Factory or field cut to match requirements of supported equipment.
4. Minimum deflection as indicated on Drawings.
5. Pad Material: Oil- and water-resistant rubber.
6. Infused nonwoven cotton or synthetic fibers.
7. Load-bearing metal plates adhered to pads.
8. Sandwich-Core Material: Resilient and elastomeric.
 - a. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Novia; A Division of C&P.
 - i. Vibration Eliminator Co., Inc.
 - j. Vibration Isolation.
 - k. Vibration Management Corp.
 - l. Vibration Mountings & Controls, Inc.
2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated on Drawings.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Novia; A Division of C&P.
 - i. Vibration Eliminator Co., Inc.
 - j. Vibration Isolation.
 - k. Vibration Management Corp.
 - l. Vibration Mountings & Controls, Inc.

2. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
3. Minimum deflection as indicated on Drawings.

2.5 HOUSED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing: .
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Vibration Eliminator Co., Inc.
 - i. Vibration Isolation.
 - j. Vibration Management Corp.
 - k. Vibration Mountings & Controls, Inc.
 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 6. Minimum deflection as indicated on Drawings.
 7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi (3447 kPa).
 - b. Top housing with threaded mounting holes and internal leveling device.

2.6 RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint: .
 1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.

- h. Novia; A Division of C&P.
- i. Vibration Eliminator Co., Inc.
- j. Vibration Isolation.
- k. Vibration Management Corp.
- l. Vibration Mountings & Controls, Inc.
- 2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi (3447 kPa).
 - b. Top plate with threaded mounting holes.
 - c. Internal leveling bolt that acts as blocking during installation.
- 3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
- 4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
- 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
- 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
- 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 8. Minimum deflection as indicated on Drawings.

2.7 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing: .
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Vibration Eliminator Co., Inc.
 - i. Vibration Isolation.
 - j. Vibration Management Corp.
 - k. Vibration Mountings & Controls, Inc.
 - 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi (3447 kPa).
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 7. Minimum deflection as indicated on Drawings.

2.8 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch- (13-mm-) Thick Neoprene: .
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. California Dynamics Corporation.
 - b. Kinetics Noise Control, Inc.
 - c. Mason Industries, Inc.
 - d. Vibration Eliminator Co., Inc.
 - e. Vibration Management Corp.
 - 2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 - 3. Maximum Load Per Support: 500 psi (3447 kPa) on isolation material providing equal isolation in all directions.
 - 4. Minimum deflection as indicated on Drawings.

2.9 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch- (13-mm-) Thick Neoprene: .
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. California Dynamics Corporation.
 - b. Kinetics Noise Control, Inc.
 - c. Mason Industries, Inc.
 - d. Vibration Eliminator Co., Inc.
 - e. Vibration Management Corp.
 - f. Vibration Mountings & Controls, Inc.
 - 2. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.10 ELASTOMERIC HANGERS

- A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods: **<Insert drawing designation>**.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Novia; A Division of C&P.
 - g. Vibration Eliminator Co., Inc.
 - h. Vibration Isolation.
 - i. Vibration Management Corp.
 - j. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
4. Minimum deflection as indicated on Drawings.

2.11 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression: .

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; a brand of nVent.
 - c. California Dynamics Corporation.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Novia; A Division of C&P.
 - g. Vibration Eliminator Co., Inc.
 - h. Vibration Isolation.
 - i. Vibration Management Corp.
 - j. Vibration Mountings & Controls, Inc.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Minimum deflection as indicated on Drawings.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.12 SNUBBERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CADDY; a brand of nVent.
2. Kinetics Noise Control, Inc.
3. Mason Industries, Inc.
4. Vibration Management Corp.
5. Vibration Mountings & Controls, Inc.

- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC.
 2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
 3. Anchors in Masonry: Design in accordance with TMS 402.
 4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 5. Resilient Cushion: Maximum 1/4-inch (6-mm) air gap, and minimum 1/4 inch (6 mm) thick.

2.13 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. CADDY; a brand of nVent.
 3. California Dynamics Corporation.
 4. Hilti, Inc.
 5. Isolation Technology, Inc.
 6. TOLCO.
 7. Unistrut; Part of Atkore International.
 8. Vibration Mountings & Controls, Inc.
- B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.14 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. CADDY; a brand of nVent.
 3. Loos & Co.
 4. Vibration Mountings & Controls, Inc.
- B. Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
- C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19-16. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.15 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. CADDY; a brand of nVent.
 3. Hilti, Inc.
 4. Loos & Co.
 5. Mason Industries, Inc.
 6. TOLCO.
 7. Unistrut; Part of Atkore International.
 8. Insert manufacturer's name.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.16 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Part of Atkore International.
 2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.

- d. Powers Fasteners.
 - e. Simpson Strong-Tie Co., Inc.
 - f. Unistrut; Part of Atkore International.
 - 2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
 - C. Provide post-installed concrete anchors that have been prequalified for use in wind-load applications. Post-installed concrete anchors must comply with all requirements of ASCE/SEI 7-22, Ch. 13.
 - 1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 - 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.
 - D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp (7.46 kW) that is not vibration isolated.
 - 1. Undercut expansion anchors are permitted.
- 2.17 CONCRETE INSERTS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. B-line, an Eaton business.
 - 2. Hilti, Inc.
 - 3. Mason Industries, Inc.
 - 4. Powers Fasteners.
 - 5. Simpson Strong-Tie Co., Inc.
 - 6. Unistrut; Part of Atkore International.
 - B. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.
 - C. Comply with ANSI/MSS SP-58.
- 2.18 VIBRATION ISOLATION EQUIPMENT BASES
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CADDY; a brand of nVent.
 - 2. California Dynamics Corporation.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.
 - 5. Novia; A Division of C&P.
 - 6. Vibration Eliminator Co., Inc.
 - 7. Vibration Isolation.
 - 8. Vibration Management Corp.
 - 9. Vibration Mountings & Controls, Inc.
 - B. Steel Rails: Factory-fabricated, welded, structural-steel rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- D. Concrete Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 - b. Concrete inertia bases shall be formed of stone aggregate concrete, with a density no less than 150 lb/ft³, and appropriate steel reinforcing cast between the perimeter structural steel channels. Inertia bases shall be built to form a rigid base that will not twist, deform or deflect, in any manner that would negatively affect the operation of the supported equipment or the vibration isolation mounts.
 - c. Inertia bases shall be adequately sized to support basic equipment conduits and motors plus any associated pipe elbows supports, suction diffuser and its supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure.
 - d. Inertia base depth shall be at least 1.5 times the longest dimension of the inertia base but not less than 6 inch and not more than 12 inches. The weight of the inertia base, as a minimum, shall be equal to or greater than that of the total weight of the equipment being isolated (including the attached piping it is supporting and applicable loads).
 - e. Forms shall include minimum concrete reinforcing of 1/2 inch bars welded in place, 6 inch on-center running in both directions at 1-1/2 inch from concrete bottom.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.19 RESTRAINED ISOLATION ROOF-CURB RAILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CADDY; a brand of nVent.
 - 2. California Dynamics Corporation.
 - 3. Kinetics Noise Control, Inc.
 - 4. Novia; A Division of C&P.
 - 5. Thybar Corporation.
 - 6. Vibration Eliminator Co., Inc.
 - 7. Vibration Management Corp.
 - 8. Vibration Mountings & Controls, Inc.
- B. Description: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment.
- C. Upper Frame: Shall provide continuous and captive support for equipment.
- D. Lower Support Assembly: Shall be formed sheet metal section containing adjustable and removable steel springs that support upper frame. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials and shall be insulated with a minimum of 2 inches (50 mm) of rigid glass-fiber insulation on inside of assembly.
 - 1. Adjustable, restrained-spring isolators shall be mounted on elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with integrity of roof.
 - 2. Minimum deflection as indicated on Drawings.
- E. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind-load forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROL DEVICES

- A. Provide vibration control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 3000 "Cast-in-Place Concrete."
- C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- D. Comply with requirements in Section 07 7200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- E. Equipment Restraints:
 - 1. Install snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 3. Install wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- G. Install wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.
- H. Install wind-load-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

- K. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- L. Post-Installed Concrete Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL MOTION

- A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties" for piping flexible connections.

3.5 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

- A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 3000 "Cast-in-Place Concrete."
- B. Coordinate dimensions of equipment bases with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate isolated equipment.

3.6 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
 - 9. Test and adjust restrained-air-spring isolator controls and safeties.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Prepare test and inspection reports.

3.8 VIBRATION AND ISOLATION CONTROL DEVICE SCHEDULE

END OF SECTION

SECTION 23 0553 - IDENTIFICATION FOR HVAC, PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Stencils.
 - 6. Valve tags.
 - 7. Warning tags.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.
 - d. Champion America.
 - e. Craftmark Identification Systems.
 - f. emedco.
 - g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Marking Services Inc.
 - j. Seton Identification Products.
 - 2. Material and Thickness: stainless steel, 0.025-inch (0.64-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 3. Letter Color: White.
 - 4. Background Color: Black.

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number, and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. Carlton Industries, L.P.
 4. Champion America.
 5. Craftmark Identification Systems.
 6. emedco.
 7. LEM Products Inc.
 8. Marking Services Inc.
 9. NMC.
 10. Seton Identification Products.
 11. Stranco, Inc.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- C. Letter Color: Red.
- D. Background Color: White.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- G. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.

- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Identification Systems.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Services Inc.
 - 11. Seton Identification Products.
 - 12. Insert manufacturer's name.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1, with following modifications -
 - 1. Equipment Drains:
 - a. Background Color: Green.
 - b. Text Color: White.
 - 2. Low pressure steam including Relief, vent and steam valve discharge:
 - a. Background Color: Orange.
 - b. Text Color: Black.
 - 3. Hot water Supply and Return:
 - a. Background Color: Yellow.
 - b. Text Color: Black.
 - 4. Chilled Water Supply and Return:
 - a. Background Color: Blue.
 - b. Text Color: White.
 - 5. Energy Recovery Coil Supply and Return:
 - a. Background Color: Yellow.
 - b. Text Color: Black.
 - 6. Natural Gas Piping:
 - a. Background Color: Yellow.
 - b. Text Color: Black.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping.

2.4 DUCT LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Carlton Industries, L.P.
 - 4. Champion America.
 - 5. Craftmark Identification Systems.
 - 6. emedco.
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Seton Identification Products.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- C. Letter Color: Blue.
- D. Background Color: White.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- G. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel rivets or self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 STENCILS

A. Stencils for Piping:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brimar Industries, Inc.
 - b. Carlton Industries, LP.
 - c. Champion America.
 - d. Craftmark Identification Systems.
 - e. Kolbi Pipe Marker Co.
 - f. Marking Services Inc.
2. Lettering Size: Size letters according to ASME A13.1 for piping.
3. Stencil Material: Aluminum.
4. Identification Paint: Exterior, in colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form. Comply with following Color Coding:
 - a. Equipment Drains:
 - 1) Background Color: Green.
 - 2) Text Color: White
 - b. Low pressure steam including Relief, vent and steam valve discharge:
 - 1) Background Color: Orange.
 - 2) Text Color: Black
 - c. Hot water Supply and Return:
 - 1) Background Color: Yellow.
 - 2) Text Color: Black
 - d. Chilled Water Supply and Return:
 - 1) Background Color: Blue.
 - 2) Text Color: White
 - e. Energy Recovery Coil Supply and Return:
 - 1) Background Color: Yellow.
 - 2) Text Color: Black
 - f. Natural Gas Piping:
 - 1) Background Color: Yellow.
 - 2) Text Color: Black

B. Stencils for Ducts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.
 - a. Brimar Industries, Inc.
 - b. Carlton Industries, LP.
 - c. Champion America.
 - d. Craftmark Identification Systems.
 - e. Kolbi Pipe Marker Co.
 - f. Marking Services Inc.
3. Lettering Size: Minimum letter height of 1-1/4 inches (32 mm) for viewing distances up to 15 feet (4-1/2 m) and proportionately larger lettering for greater viewing distances.
4. Stencil Material: Aluminum.

5. Identification must be either stenciled onto the system with an oil-based paint or with pressure sensitive vinyl markers with permanent adhesive. Provide full-band duct markers extending 360 degrees around a duct.
- C. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Brimar Industries, Inc.
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Craftmark Identification Systems.
 - d. Kolbi Pipe Marker Co.
 - e. Marking Services Inc.
 3. Lettering Size: Minimum letter height of 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.
 4. Stencil Material: Aluminum.
 5. Identification must be either stenciled onto the system with an oil-based paint or with pressure sensitive vinyl markers with permanent adhesive.

2.6 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Actioncraft Products, Inc.
 2. Brady Corporation.
 3. Brimar Industries, Inc.
 4. Carlton Industries, LP.
 5. Champion America.
 6. Craftmark Identification Systems.
 7. emedco.
 8. Kolbi Pipe Marker Co.
 9. LEM Products Inc.
 10. Marking Services Inc.
 11. Seton Identification Products.
- B. Description: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
1. Tag Material: stainless steel, 0.025-inch (0.64-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link chain or beaded chain.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. g:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Carlton Industries, LP.
 - 4. Champion America.
 - 5. Craftmark Identification Systems.
 - 6. emedco.
 - 7. Kolbi Pipe Marker Co.
 - 8. LEM Products Inc.
 - 9. Marking Services Inc.
 - 10. Seton Identification Products.
- C. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches (100 by 178 mm).
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in Section 09 9123 "Interior Painting." Section 09 9600 "High-Performance Coatings."
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Pipe Label Locations: Provide identification at following locations -
 - 1. All exposed piping
 - a. All exposed piping within 0.5 m (18 in) of each valve .
 - b. All exposed piping within 75 mm (3 in) of each 90-degree elbow, connection to equipment or vessel, point where pipe enters shaft to upper floors, and point where pipe pierces outside wall.
 - c. All exposed piping within 75 mm (3 in) of each 90-degree elbow, connection to equipment or vessel, point where pipe enters shaft to upper floors, and point where pipe pierces outside wall.
 - d. Omit identification on piping 40 mm (1 ½ in) size and smaller exposed at connections to equipment .
 - 2. Above suspended ceilings:
 - a. Within 0.5 m (18 in) of each valve or valve assembly.
 - b. At tees, both main and branch must be identified within 7.6 m (25 ft) of tee.
 - c. Within 0.9 m (3 ft) of each 90-degree elbow.
 - d. Minimum of one label per room (each side of partition).
 - 3. Pipe concealed in cases or shafts -
 - a. Identify each pipe visible through access door panel / ceiling tile.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Arrows showing the direction of flow must be painted on the piping near the location of each piping identification label.

3.5 DUCT LABEL INSTALLATION

- A. Duct Label Location - Identify ductwork at following locations
 - 1. All exposed ductwork
 - a. All exposed ductwork within 0.5 m (18 in) of fire smoke and/or main isolation damper.
 - b. Minimum of one label per opaque partition (each side of partition).
 - 2. Above suspended ceilings:
 - a. Within 0.5 m (18 in) of each terminal unit (or terminal unit assembly with heating coil).
 - b. At tees, both main and branch must be identified within 7.6 m (25 ft) of tee.
 - c. Minimum of one label per opaque partition (each side of partition).
 - 3. Pipe concealed in cases or shafts -

- B. Identify each primary duct main visible through access door panel / ceiling tile.
- C. Stenciled Duct Label Option: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.
- D. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet (15 m) in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Chilled Water: 2 inches (50 mm), round.
 - b. Hot Water: 2 inches (50 mm), round.
 - c. Gas: 2 inches (50 mm), round.
 - d. Low-Pressure Steam: 2 inches (50 mm), round.
 - e. Steam Condensate: 2 inches (50 mm), round.
 - 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
 - b. Flammable Fluids: Black letters on a safety-yellow background.
 - c. Combustible Fluids: White letters on a safety-brown background.
 - d. Potable and Other Water: White letters on a safety-green background.
 - e. Compressed Air: White letters on a safety-blue background.
 - f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background

3.7 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
2. Balancing Hydronic Piping Systems:
 - a. Variable-flow hydronic systems.
 - b. Primary-secondary hydronic systems.
3. Balancing steam systems.
4. Testing, Adjusting, and Balancing Equipment:
 - a. Heat exchangers.
 - b. Motors.
 - c. Chillers.
 - d. Condensing units.
 - e. Boilers.
 - f. Heat-transfer coils.
5. Testing, adjusting, and balancing existing systems and equipment.
6. Sound tests.
7. Vibration tests.
8. Duct leakage tests.
9. Control system verification.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.3 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at 3001 Connecticut Ave. NW, Washington, D.C. 20008 after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
1. Minimum Agenda Items:
 - a. The Contract Documents examination report.

- b. The TAB plan.
- c. Needs for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

1.4 ACTION SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. HVAC Flush Report: Documentation indicating that building HVAC system flush complies with Green Globes Section 3.2.4.4 "IAQ During Construction."
 - 1. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.
 - 5. Dates of calibration.

1.6 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC as a TAB technician.

- B. TAB Specialists Qualifications: Certified by NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by NEBB or TABB as a TAB technician.
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.7 FIELD CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
 - G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
 - H. Examine test reports specified in individual system and equipment Sections.
 - I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
 - J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
 - K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
 - L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
 - M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
 - N. Examine system pumps to ensure absence of entrained air in the suction piping.
 - O. Examine operating safety interlocks and controls on HVAC equipment.
 - P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.
- 3.2 PREPARATION
- A. Prepare a TAB plan that includes the following:
 1. Equipment and systems to be tested.
 2. Strategies and step-by-step procedures for balancing the systems.
 3. Instrumentation to be used.
 4. Sample forms with specific identification for all equipment.
 - B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.

- g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning per the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 3300 "Air Duct Accessories."
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 0713 "Duct Insulation," Section 23 0716 "HVAC Equipment Insulation," and Section 23 0719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.

- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 3113 "Metal Ducts."

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Adjust the variable-air-volume systems as follows:
 - 1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
 - 2. Verify that the system is under static pressure control.
 - 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 1. Check liquid level in expansion tank.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.

4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.7 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
 1. Verify that the differential-pressure sensor is located as indicated.
 2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
 1. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
 2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 5. For systems without pressure-independent valves or flow-measuring devices at terminals:

- a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 6. Prior to verifying final system conditions, determine the system differential-pressure set point.
 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 8. Mark final settings and verify that all memory stops have been set.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
 10. Verify that memory stops have been set.
- D. For systems with diversity:
1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
 3. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
 4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.

6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
13. Verify that memory stops have been set.

3.8 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first.
- B. Balance the secondary circuits after the primary circuits are complete.
- C. Adjust pumps to deliver total design gpm.
 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
 1. Measure flow in main and branch pipes.

2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- H. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- I. Verify that memory stops have been set.
- 3.9 PROCEDURES FOR STEAM SYSTEMS
- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.
- 3.10 PROCEDURES FOR MOTORS
- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.

- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.
- C. Electronically Communicated Motors in Terminal Units: Test for proper operation at airflows ranging from minimum to maximum. Incrementally increase minimum airflow as required until the fan static pressure is within the manufacturers specified range and stable operation is achieved. Record observations including terminal unit tag and final minimum airflow.

3.11 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
 - 5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
 - 6. Capacity: Calculate in tons of cooling.
 - 7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.12 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.13 PROCEDURES FOR BOILERS

- A. Hydronic Boilers:
 - 1. Measure and record entering- and leaving-water temperatures.
 - 2. Measure and record water flow.
 - 3. Record relief valve pressure setting.
- B. Steam Boilers:
 - 1. Measure and record entering-water temperature.
 - 2. Measure and record feed water flow.
 - 3. Measure and record leaving-steam pressure and temperature.
 - 4. Record relief valve pressure setting.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
 2. Water flow rate.
 3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
 4. Dry-bulb temperature of entering and leaving air.
 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 6. Airflow.
- B. Measure, adjust, and record the following data for each electric heating coil:
1. Nameplate data.
 2. Airflow.
 3. Entering- and leaving-air temperature at full load.
 4. Voltage and amperage input of each phase at full load.
 5. Calculated kilowatt at full load.
 6. Fuse or circuit-breaker rating for overload protection.
- C. Measure, adjust, and record the following data for each steam coil:
1. Dry-bulb temperature of entering and leaving air.
 2. Airflow.
 3. Inlet steam pressure.
- D. Measure, adjust, and record the following data for each refrigerant coil:
1. Dry-bulb temperature of entering and leaving air.
 2. Wet-bulb temperature of entering and leaving air.
 3. Airflow.
- 3.15 SOUND TESTS
- A. After the systems are balanced and construction is Substantially Complete, measure and record sound levels at 10 locations as designated by the Architect.
- B. Instrumentation:
1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.
 2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (LEQ).
 3. The sound-testing meter must be capable of using 1/3 octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
 4. The accuracy of the sound-testing meter shall be plus or minus one decibel.
- C. Test Procedures:
1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
 2. Equipment should be operating at design values.
 3. Calibrate the sound-testing meter prior to taking measurements.
 4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
 5. Record a set of background measurements in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment off.
 6. Take sound readings in dBA and sound pressure levels in the eight un-weighted octave bands 63 Hz to 8000 Hz (NC) with the equipment operating.

7. Take readings no closer than 36 inches (900 mm) from a wall or from the operating equipment and approximately 60 inches (1500 mm) from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
 - a. Location.
 - b. System tested.
 - c. dBA reading.
 - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on NC worksheet with equipment on and off.

3.16 VIBRATION TESTS

- A. After systems are balanced and construction is Substantially Complete, measure and record vibration levels on equipment having motor horsepower equal to or greater than 10.

B. Instrumentation:

1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
4. Verify calibration date is current for vibration meter before taking readings.

C. Test Procedures:

1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
4. Record CPM or rpm.
5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.

D. Reporting:

1. Report shall record location and the system tested.
2. Include horizontal-vertical-axial measurements for tests.
3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from the AABC National Standards. Acceptable levels of vibration are normally "smooth" to "good."

4. Include in report General Machinery Vibration Severity Chart, with conditions plotted.

3.17 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.18 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 1. Verify temperature control system is operating within the design limitations.
 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 3. Verify that controllers are calibrated and function as intended.
 4. Verify that controller set points are as indicated.
 5. Verify the operation of lockout or interlock systems.
 6. Verify the operation of valve and damper actuators.
 7. Verify that controlled devices are properly installed and connected to correct controller.
 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.19 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus or minus 10 percent.
 3. Heating-Water Flow Rate: Plus or minus 10 percent.
 4. Cooling-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.21 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - 12. Nomenclature sheets for each item of equipment.
 - 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 - 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 - 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.

- h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
 - 1. Quantities of outdoor, supply, return, and exhaust airflows.
 - 2. Water and steam flow rates.
 - 3. Duct, outlet, and inlet sizes.
 - 4. Pipe and valve sizes and locations.
 - 5. Terminal units.
 - 6. Balancing stations.
 - 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches (mm), and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static-pressure differential in inches wg (Pa).
 - f. Preheat-coil static-pressure differential in inches wg (Pa).
 - g. Cooling-coil static-pressure differential in inches wg (Pa).
 - h. Heating-coil static-pressure differential in inches wg (Pa).
 - i. Outdoor airflow in cfm (L/s).
 - j. Return airflow in cfm (L/s).
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.
- F. Apparatus-Coil Test Reports:
 - 1. Coil Data:
 - a. System identification.
 - b. Location.

- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch (mm) o.c.
- f. Make and model number.
- g. Face area in sq. ft. (sq. m).
- h. Tube size in NPS (DN).
- i. Tube and fin materials.
- j. Circuiting arrangement.
- 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
 - e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - h. Water flow rate in gpm (L/s).
 - i. Water pressure differential in feet of head or psig (kPa).
 - j. Entering-water temperature in deg F (deg C).
 - k. Leaving-water temperature in deg F (deg C).
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig (kPa).
 - n. Refrigerant suction temperature in deg F (deg C).
 - o. Inlet steam pressure in psig (kPa).
- G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Output capacity in Btu/h (kW).
 - h. Ignition type.
 - i. Burner-control types.
 - j. Motor horsepower and rpm.
 - k. Motor volts, phase, and hertz.
 - l. Motor full-load amperage and service factor.
 - m. Sheave make, size in inches (mm), and bore.
 - n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 2. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Entering-air temperature in deg F (deg C).
 - c. Leaving-air temperature in deg F (deg C).
 - d. Air temperature differential in deg F (deg C).
 - e. Entering-air static pressure in inches wg (Pa).
 - f. Leaving-air static pressure in inches wg (Pa).
 - g. Air static-pressure differential in inches wg (Pa).
 - h. Low-fire fuel input in Btu/h (kW).

- i. High-fire fuel input in Btu/h (kW).
 - j. Manifold pressure in psig (kPa).
 - k. High-temperature-limit setting in deg F (deg C).
 - l. Operating set point in Btu/h (kW).
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in Btu/h (kW).
- H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in Btu/h (kW).
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm (L/s).
 - i. Face area in sq. ft. (sq. m).
 - j. Minimum face velocity in fpm (m/s).
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h (kW).
 - b. Airflow rate in cfm (L/s).
 - c. Air velocity in fpm (m/s).
 - d. Entering-air temperature in deg F (deg C).
 - e. Leaving-air temperature in deg F (deg C).
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).

- c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
- 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated airflow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual airflow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- K. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft. (sq. m).
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
- L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
- 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. Water pressure drop in feet of head or psig (kPa).

- e. Entering-air temperature in deg F (deg C).
 - f. Leaving-air temperature in deg F (deg C).
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump rpm.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).
 - e. Full-open pressure in feet of head or psig (kPa).
 - f. Final discharge pressure in feet of head or psig (kPa).
 - g. Final suction pressure in feet of head or psig (kPa).
 - h. Final total pressure in feet of head or psig (kPa).
 - i. Final water flow rate in gpm (L/s).
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- N. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.22 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Owner, Construction Manager and Commissioning Authority.

- B. Owner Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
1. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- C. Recheck the following measurements in their entirety:
1. Airside:
 - a. All outside air intake flow rates
 - b. All exhaust/relief flow rates
 - c. Supply, return, relief and exhaust airflow rates (as applicable) for all AHUs / RTU/s / DOAUs in the entire project
 - d. 10 percent of all other measurements recorded as randomly selected by the Architect. Submit RFI to the Architect to identify the associated measurements that need to be rechecked.
 2. Waterside:
 - a. Pump performance for all pumps, in all hydronic systems in the project.
 - b. Hydronic coil balancing for all coils in AHUs / RTU/s / DOAUs with a minimum design airflow of 5,000 CFM, in the entire project.
 - c. 10 percent of all other measurements recorded as randomly selected by the Architect. Submit RFI to the Architect to identify the associated measurements that need to be rechecked.
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
 3. If the second verification also fails, Owner may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.
- 3.23 ADDITIONAL TESTS
- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 0713 - DUCT INSULATION**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 5. Outdoor, exposed supply and return.
- B. Related Requirements:
 - 1. Section 23 0716 "HVAC Equipment Insulation."
 - 2. Section 23 0719 "HVAC Piping Insulation."
 - 3. Section 23 3113 "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Data: For adhesives, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 4. Product Data: For coatings, indicating VOC content.
 - 5. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
 - 6. Product Data: For sealants, indicating VOC content.
 - 7. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 - 2. Sheet Jacket Materials: 12 inches (300 mm) square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral Wool Blanket: Basalt volcanic rock-derived fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F (650 deg C) in accordance with ASTM C447. Comply with ASTM C553.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. ROCKWOOL Technical Insulation.
- G. Mineral Wool Board: Basalt volcanic rock-derived fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1100 deg F (600 deg C) in accordance with ASTM C411. Comply with ASTM C612, Type III, unfaced.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. ROCKWOOL Technical Insulation.
- H. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F (538 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. ROCKWOOL.
 - 2. Semirigid board material with factory-applied ASJ jacket.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

- B. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. Fiberglass adhesive shall have a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.

2.4 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
1. VOC Content: 300 g/L or less.
 2. VOC Content: 300 g/L or less.
 3. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. VOC Content: 300 g/L or less.

5. Low-Emitting Materials: Mastic coatings shall comply with the requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. VOC Content: 300 g/L or less.
 7. Low-Emitting Materials: Mastic coatings shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 8. VOC Emissions: Mastic coatings shall contain no more than half of the chronic REL of VOCs when tested according to the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit or 33 mcg/cu. m and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Vimasco Corporation.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 5. Color: White.
- C. Vapor-Retarder Mastic, Solvent Based, Interior Use: Suitable for indoor use on below ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Color: White.
- D. Vapor-Retarder Mastic, Solvent Based, Exterior Use: Suitable for outdoor use on below ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.

- c. Foster Brand; H. B. Fuller Construction Products.
 - 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Knauf Insulation.
 - e. Mon-Eco Industries, Inc.
 - f. Vimasco Corporation.
 - 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perm) at manufacturer's recommended dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Color: White.

2.5 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
 - 2. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 - 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 - 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
7. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
8. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
9. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
2. Materials are compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
10. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
2. Materials are compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.

- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.

2.9 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Alpha Associates, Inc.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Sekisui Voltek, LLC.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.11 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) CL WARD & Family Inc.
 - 3) Gemco.
 - 4) Midwest Fasteners, Inc.
 - 5) Nelson Stud Welding.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, stainless steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
 - D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.
- 2.12 CORNER ANGLES
- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
 - B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum in accordance with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
 - C. Stainless Steel Corner Angles: Insert dimension thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Exposed indoor ductwork must be insulated with a semi-rigid insulation with white kraft ALL Service Jacket (ASJ) bonded to aluminum foil, with a white paintable finish.
- B. Install paintable canvas wrapping on all ductwork located within the mechanical rooms and exposed ductwork in occupied spaces. Coordinate paint colors in all spaces with the COTR and Architect.
- C. Concealed indoor ductwork must be insulated with either semi-rigid or flexible fibrous duct wrap with Foil Scrim Kraft (FSK) and formaldehyde free bonding resin.
- D. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- E. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- F. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- G. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- H. Install multiple layers of insulation with longitudinal and end seams staggered.
- I. Keep insulation materials dry during application and finishing.
- J. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- K. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- L. Install insulation with least number of joints practical.

- M. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- N. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- O. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [2 inches (50 mm)] [4 inches (100 mm)] o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- P. Cut insulation in a manner to avoid compressing insulation.
- Q. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- R. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.

- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).
 - 1. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
 - 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 INSTALLATION OF GLASS-FIBER AND MINERAL-WOOL INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- B. Comply with manufacturer's written installation instructions.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.

- f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
 - 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 - 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- C. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches (300 mm) o.c. and at end joints.

3.7 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."
 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

- a. Finish Coat Material: Interior, flat, latex-emulsion size.
 - B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 - C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
 - D. Do not field paint aluminum or stainless steel jackets.
- 3.8 FIELD QUALITY CONTROL
- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - B. Perform tests and inspections.
 - C. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
- 3.9 DUCT INSULATION SCHEDULE, GENERAL
- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 4. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 5. Outdoor, concealed supply and return.
 - 6. Outdoor, exposed supply and return.
 - B. Items Not Insulated:
 - 1. Factory-insulated flexible ducts.
 - 2. Factory-insulated plenums and casings.
 - 3. Flexible connectors.
 - 4. Vibration-control devices.
 - 5. Factory-insulated access panels and doors.
- 3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE
- A. Concealed, round and flat-oval, supply-air duct insulation is one of the following:
 - 1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 - B. Concealed, round and flat-oval, outdoor-air duct insulation is one of the following:
 - 1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.

- C. Concealed, round and flat-oval, exhaust-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- D. Concealed, rectangular, supply-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- E. Concealed, rectangular, outdoor-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- F. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- G. Concealed, outdoor-air plenum insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- H. Concealed, exhaust-air plenum insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- I. Exposed, round and flat-oval, supply-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- J. Exposed, round and flat-oval, outdoor-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- K. Exposed, round and flat-oval, exhaust-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- L. Exposed, rectangular, supply-air duct insulation is one of the following:
1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6-lb/cu. ft. (96-kg/cu. m) nominal density.

- M. Exposed, rectangular, outdoor-air duct insulation is one of the following:
 - 1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 - 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- N. Exposed, rectangular, exhaust-air duct insulation is one of the following:
 - 1. Mineral Wool Blanket: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 - 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.

3.11 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Ducts and Plenums, Concealed:
 - 1. None.
- D. Ducts and Plenums, Exposed:
 - 1. All exposed ductwork that requires insulation shall be covered with canvas wrap and painted in an exact color approved by Architect.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. All outdoor and/or exposed ductwork (including but limited to boiler flue and boiler intake) shall be covered with canvas wrap and painted in an exact custom color approved by Architect.

END OF SECTION

SECTION 23 0716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating HVAC equipment that is not factory insulated.
- B. Related Sections:
 - 1. Section 23 0713 "Duct Insulation."
 - 2. Section 23 0719 "HVAC Piping Insulation."

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Data: For sealants, indicating VOC content.
 - 3. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail removable insulation at equipment connections.
 - 2. Detail application of field-applied jackets.
 - 3. Detail application at linkages of control devices.
 - 4. Detail field application for each equipment type.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 - 2. Sheet Jacket Materials: 12 inches (300 mm) square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 - 1. Equipment Mockups:
 - a. One chilled-water pump and one heating-hot-water pump.
 - b. One tank or vessel.
 - 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 - 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 4. Obtain Architect's approval of mockups before starting insulation application.
 - 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system **materials are to be delivered to the Project site in unopened containers**. The packaging is to include, the name of the manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with equipment Installer for equipment insulation application.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule" articles for where insulating materials are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Calcium Silicate: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I or Type II.
 - 1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Johns Manville; a Berkshire Hathaway company.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Owens Corning.
 - 2. Block Insulation: Type I.
 - 3. Special-Shaped Insulation: Type III.
 - 4. Board Insulation: Type IV.
 - 5. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- H. Mineral Wool Blanket: Basalt volcanic rock-derived fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F (650 deg C) in accordance with ASTM C447. Comply with ASTM C553.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. ROCKWOOL Technical Insulation.
- I. Mineral Wool Board: Basalt volcanic rock-derived fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1100 deg F (600 deg C) in accordance with ASTM C411. Comply with ASTM C612, Type III, unfaced.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. ROCKWOOL Technical Insulation.
- J. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F (538 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. Rockwool International.
 2. Semirigid board material with factory-applied ASJFSK jacket.
 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.
- C. Glass-Fiber and Mineral Wool, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 - d. Vimasco Corporation.
 2. Adhesive: As recommended by calcium silicate manufacturer and with a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of [80]<Insert value> g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- D. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- E. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.

2. Adhesives shall have a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- F. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Proto Corporation.
 - c. Speedline Corporation.
 - d. The Dow Chemical Company.
 2. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.5 MASTICS AND COATINGS

- A. Vapor-Retarder Mastic, Water Based: Suitable for indoor and outdoor use on below-ambient services.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Color: White.
- B. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Color: White.
- C. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 4. Color: White.
- D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Vimasco Corporation.
 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.

3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Color: White.

2.6 LAGGING ADHESIVES

- A. Adhesives comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
 2. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 7. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
 8. Service Temperature Range: 20 to plus 180 deg F (Minus 6 to plus 82 deg C) 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
 9. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 - d. Owens Corning.

2. Permanently flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 4. Color: White or gray.
 5. Sealant shall have a VOC content of 420 g/L or less.
 6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- C. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: Aluminum.
 5. Sealant shall have a VOC content of 420 g/L or less.
 6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: White.
 5. Sealant shall have a VOC content of [420]<Insert value> g/L or less.
 6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.8 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: Color-code jackets based on system. Color as selected by Architect.
 - 4. Factory-fabricated tank heads and tank side panels.
- D. Metal Jacket:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - 3. Stainless Steel Jacket: ASTM A240/A240M.
 - a. Factory cut and rolled to size.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

- e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
 - f. MFM Building Products Corp.
 - g. Polyguard Products, Inc.
- E. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - 2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 - 3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 - 4. Aluminum Finish: Embossed.
- F. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested in accordance with ASTM E96/E96M and with a flame-spread index of 10 and a smoke-developed index of 20 when tested in accordance with ASTM E84.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
- G. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested in accordance with ASTM E96/E96M and with a flame-spread index of 25 and a smoke-developed index of 50 when tested in accordance with ASTM E84.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
- H. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 4 oz./sq. yd. (114 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering equipment.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.

2.11 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Alpha Associates, Inc.

2.12 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - 2. Width: 3 inches (75 mm).
 - 3. Thickness: 11.5 mils (0.29 mm).
 - 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.

- e. .
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 2 inches (50 mm).
 3. Thickness: 3.7 mils (0.093 mm).
 4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 2. Width: 3 inches (75 mm).
 3. Film Thickness: 6 mils (0.15 mm).
 4. Adhesive Thickness: 1.5 mils (0.04 mm).
 5. Elongation at Break: 145 percent.
 6. Tensile Strength: 55 psi (379 kPa) in width.
- F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 2. Width: 3 inches (75 mm).
 3. Film Thickness: 6 mils (0.15 mm).
 4. Adhesive Thickness: 1.5 mils (0.04 mm).
 5. Elongation at Break: 145 percent.

6. Tensile Strength: 55 psi (379 kPa) in width.

2.13 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with wing seal or closed seal.
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) CL WARD & Family Inc.
 - 3) Gemco.
 - 4) Midwest Fasteners, Inc.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Use product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Stainless steel, fully annealed; 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
 6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, stainless steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - 5) .
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.
 - b. Johns Manville; a Berkshire Hathaway company.

- c. RPR Products, Inc.
- d. .

2.14 CORNER ANGLES

- A. PVC Corner Angles: 30-mils- (0.8-mm-) thick, minimum 1- by 1-inch (25- by 25-mm) PVC in accordance with ASTM D1784, Class 16354-C, white or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040-inch- (1.0-mm-) thick, minimum 1- by 1-inch (25- by 25-mm) aluminum in accordance with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless Steel Corner Angles: 0.024-inch- (0.61-mm-) thick, minimum 1- by 1-inch (25- by 25-mm) stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range of between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches (50 mm) o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.

5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- O. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

- A. Mineral WoolGlass-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.
1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints and 16 inches (400 mm) o.c. in both directions.
 - d. Do not compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins, and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.

6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
2. Fabricate boxes from stainless steel, at least 0.060 inch (1.6 mm) thick.
3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Boiler Breechings:

1. Secure single-layer insulation with stainless steel bands at 12-inch (300-mm) intervals, and tighten bands without deforming insulation material.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless steel bands at 12-inch (300-mm) intervals.
3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.

- B. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches (300 mm) o.c. and at end joints.
- E. Where PVDC jackets are indicated, install as follows:
1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
 2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.7 FINISHES

- A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.8 FIELD QUALITY CONTROL

- A. Engage a qualified testing agency to perform tests and inspections.

- B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to one location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule" articles. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.9 EQUIPMENT INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials is Contractor's option.

3.10 INDOOR EQUIPMENT INSULATION SCHEDULE

- A. Insulate indoor and outdoor equipment that is not factory insulated.
- B. Chilled-water pump insulation is one of the following:
 - 1. Cellular Glass: 3 inches (75 mm) thick.
 - 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- C. Heating-hot-water pump insulation is one of the following:
 - 1. Calcium Silicate: 3 inches (75 mm) thick.
 - 2. Cellular Glass: 3 inches (75 mm) thick.
 - 3. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- D. Heat-recovery pump insulation is one of the following:
 - 1. Cellular Glass: 2 inches (50 mm) thick.
 - 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
- E. Chilled-water expansion/compression tank insulation is one of the following:
 - 1. Cellular Glass: 3 inches (75 mm) thick.
 - 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 - 3. Mineral Wool Pipe and Tank: 1.5 inches (38 mm) thick.
- F. Heating-hot-water expansion/compression tank insulation is one of the following:
 - 1. Calcium Silicate: 2 inches (50 mm) thick.
 - 2. Cellular Glass: 2 inches (50 mm) thick.
 - 3. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 - 4. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- G. Heat-recovery expansion/compression tank insulation is one of the following:
 - 1. Cellular Glass: 2 inches (50 mm) thick.
 - 2. Mineral Wool Board: 1 inch (25 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.

3. Mineral Wool Pipe and Tank: 1.5 inches (38 mm) thick.
- H. Chilled-water air-separator insulation is one of the following:
1. Cellular Glass: 2 inches (50 mm) thick.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 3. Mineral Wool Pipe and Tank: 1.5 inches (38 mm) thick.
- I. Heating-hot-water air-separator insulation is one of the following:
1. Calcium Silicate: 3 inches (75 mm) thick.
 2. Cellular Glass: 3 inches (75 mm) thick.
 3. Mineral Wool Board: 2 inches (50 mm) thick and [4 lb/cu. ft. (64 kg/cu. m)][6 lb/cu. ft. (96 kg/cu. m)]<Insert density> nominal density.
 4. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- J. Heat-recovery air-separator insulation is one of the following:
1. Cellular Glass: 2 inches (50 mm) thick.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 4 lb/cu. ft. (64 kg/cu. m) nominal density.
 3. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- K. Thermal storage tank (brine, water, ice), buffer tank insulation is one of the following:
1. Cellular Glass: 4 inches (100 mm) thick.
 2. Mineral Wool Board: 3 inches (75 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 3. Mineral Wool Pipe and Tank: 3 inches (75 mm) thick.
 4. Polystyrene (Outdoor Application Only): 3 inches (75 mm) thick.
- L. Piping system filter-housing insulation is one of the following:
1. Cellular Glass: 3 inches (75 mm) thick.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 3. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- 3.11 OUTDOOR, ABOVEGROUND EQUIPMENT INSULATION SCHEDULE
- A. Retain "one of" option in paragraph below to allow Contractor to select materials from those retained. Heated, fuel-oil storage tank insulation is one of the following:
1. Cellular Glass: 3 inches (75 mm) thick.
 2. Mineral Wool Board: 2 inches (50 mm) thick and 6 lb/cu. ft. (96 kg/cu. m) nominal density.
 3. Mineral Wool Pipe and Tank: 2 inches (50 mm) thick.
- 3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE
- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:
1. PVC, Color-Coded by System: 30 mils (0.8 mm) thick.
 2. Painted Aluminum, Stucco Embossed: 0.032 inch (0.81 mm) thick.
 3. Stainless Steel, Type 304 or Type 316, Stucco Embossed: 0.020 inch (0.51 mm) thick.

- D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
 - 1. PVC, Color-Coded by System: 30 mils (0.8 mm) thick.
 - 2. Painted Aluminum, Stucco Embossed: 0.032 inch (0.81 mm) thick.
 - 3. Stainless Steel, [Type 304][or][Type 316], Stucco Embossed: 0.024 inch (0.61 mm) thick.
- E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - 1. Painted Aluminum, Stucco Embossed with 2-1/2-Inch- (65-mm-) Deep Corrugations: 0.040 inch (1.0 mm) thick.
 - 2. Stainless Steel, Type 304orType 316, Stucco Embossed, with 2-1/2-Inch- (65-mm-) Deep Corrugations: 0.024 inch (0.61 mm) thick.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - 1. Painted Aluminum, Stucco Embossed with 2-1/2-Inch- (65-mm-) Deep Corrugations: 0.040 inch (1.0 mm) thick.
 - 2. Stainless Steel, Type 304orType 316, Stucco Embossed, with 2-1/2-Inch- (65-mm-) Deep Corrugations: [0.020 inch (0.51 mm)][0.024 inch (0.61 mm)] thick.

END OF SECTION

SECTION 23 0719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulation for HVAC piping systems.
- B. Related Requirements:
 - 1. Section 23 0713 "Duct Insulation" for duct insulation.
 - 2. Section 23 0716 "HVAC Equipment Insulation" for equipment insulation.
 - 3. Section 23 2113.13 "Underground Hydronic Piping" loose-fill pipe insulation in underground piping outside the building.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied, if any).
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
 - 2. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 - 1. Piping Mockups:
 - a. One 10-foot (3-m) section of NPS 2 (DN 50) straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.
 - d. One NPS 2 (DN 50) or smaller valve and one NPS 2-1/2 (DN 65) or larger valve.
 - e. Four support hangers, including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - j. One union.
 - 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 - 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 4. Obtain Architect's approval of mockups before starting insulation application.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Calcium Silicate: Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I.
 - 1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Johns Manville; a Berkshire Hathaway company.
- G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Owens Corning.
 - 2. Preformed Pipe Insulation without Jacket: Type II, Class 1, unfaced.
 - 3. Preformed Pipe Insulation with Jacket: Type II, Class 2, with factory-applied ASJ jacket.
 - 4. Fabricated shapes in accordance with ASTM C450, ASTM C585, and ASTM C1639.
 - 5. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Mineral Wool, Preformed Pipe: Mandrel-wound mineral wool fibers bonded with a thermosetting resin, unfaced; suitable for maximum use temperature up to 1200 deg F (650 deg C) in accordance with ASTM C447. Comply with ASTM C547.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.

- b. Owens Corning.
 - c. ROCKWOOL Technical Insulation.
 - 2. Preformed Pipe Insulation: Type II, Grade A, unfaced with factory-applied ASJ.
 - 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - I. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F (538 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Owens Corning.
 - c. Rockwool International.
 - 2. Semirigid board material with factory-applied ASJ jacket.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - J. Polyisocyanurate: Prefabricated, rigid cellular polyisocyanurate material intended for use as thermal insulation. Comply with ASTM C591.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. .
 - 2. Prefabricated insulation, with factory-applied ASJ.
 - 3. Type IV, except thermal conductivity (k-value) do not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - 4. Flame-spread index is 25 or less, and smoke-developed index is 50 or less for thicknesses of up to 1.5 inch (38 mm) as tested in accordance with ASTM E84.
 - 5. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 6. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - K. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type I, Grade 1, for tubular materials and with Type II, Grade 1, for sheet materials, self-seal.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armacell LLC.
 - b. Nomaco.
- 2.2 INSULATING CEMENTS
- A. Mineral Wool Insulating Cement: Comply with ASTM C195.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.
 - B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.
 - C. Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ramco Insulation, Inc.

2.3 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 - d. Vimasco Corporation.
 2. Adhesive: As recommended by calcium silicate manufacturer and with a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- C. Polyolefin Adhesive: Solvent-based adhesive.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
 2. Adhesive: As recommended by flexible elastomeric and polyolefin manufacturer and with a VOC content of 80 g/L or less.

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
 8. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 9. Wet Flash Point: Below 0 deg F (minus 18 deg C).
 10. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).
 11. Color: Black.
- D. Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.

6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- E. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Adhesive: As recommended by polystyrene manufacturer and with a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- F. ASJ Adhesive and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Adhesives shall have a VOC content of 50 g/L or less.

3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
7. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.4 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
2. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
3. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
4. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
5. Mastics shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

B. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 5. Color: White.
- C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Color: White.
- D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 4. Color: White.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perm) at manufacturer's recommended dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Color: White.

2.5 LAGGING ADHESIVES

- A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
2. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
4. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
6. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
7. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
8. Service Temperature Range: 20 to plus 180 deg F (Minus 6 to plus 82 deg C) 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
9. Color: White.

2.6 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 - d. Owens Corning.
 2. Permanently flexible, elastomeric sealant.
 - a. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
 - b. Color: White or gray.
 3. Sealant shall have a VOC content of 420 g/L or less.

4. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 5. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.
- C. FSK and Metal Jacket Flashing Sealants:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Mon-Eco Industries, Inc.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: Aluminum.
 5. Sealant shall have a VOC content of 420 g/L or less.
 6. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 8. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." The building concentration of formaldehyde shall not exceed half of the indoor recommended exposure limit, or 33 mcg/cu. m, and that of acetaldehyde shall not exceed 9 mcg/cu. m.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

2.8 FIELD-APPLIED JACKETS

- A. Metal Jacket:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- B. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane, consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Owens Corning.
 - b. Polyguard Products, Inc.

- C. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 4. Aluminum Finish: Embossed.

2.9 FIELD-APPLIED FABRIC REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.

2.10 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Alpha Associates, Inc.

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).

4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. .
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 2 inches (50 mm).
 3. Thickness: 3.7 mils (0.093 mm).
 4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.12 SECUREMENTS

- A. Bands:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 2. Stainless Steel: ASTM A240/A240M, Type 304or; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing sealorclosed seal.
 3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 3/4 inch (19 mm) wide with [wing seal][or][closed seal].
 4. Springs: Twin spring set constructed of stainless steel, with ends flat and slotted to accept metal bands. Spring size is determined by manufacturer for application.
- B. Staples: Outward-clinching insulation staples, nominal 3/4 inch (19 mm) wide, stainless steel or Monel.

- C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy 0.062-inch (1.6-mm) soft-annealed, stainless steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Indoor piping - Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Outdoor piping - Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at [2 inches (50 mm)][4 inches (100 mm)] o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation.

- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.

2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using prefabricated fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with prefabricated fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using prefabricated fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using prefabricated fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions using a section of oversized preformed pipe insulation to fit. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.

- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation conforms to the following:
 - 1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 - 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 - 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 - 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 - 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 - 1. Secure single-layer insulation with stainless steel bands at 12-inch (300-mm) intervals, and tighten bands without deforming insulation materials.
 - 2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless steel bands at 12-inch (300-mm) intervals.
 - 3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install prefabricated pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
 - 4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When prefabricated insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install pipe insulation, quads, hex sections, or beveled lag segments, adhered together, of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered or routed sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF GLASS-FIBER AND MINERAL WOOL INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of preformed pipe insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
 4. For insulation with jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.
- B. Insulation Installation on Pipe Flanges:
1. Install prefabricated pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber or mineral-wool blanket insulation.
 4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.
- C. Insulation Installation on Pipe Fittings and Elbows:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- D. Insulation Installation on Valves and Pipe Specialties:
1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
 2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
 3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 4. Install insulation to flanges as specified for flange insulation application.

3.9 INSTALLATION OF PHENOLIC INSULATION

- A. General Installation Requirements:
1. Secure single-layer insulation with stainless steel bands at 12-inch (300-mm) intervals, and tighten bands without deforming insulation materials.
 2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless steel bands at 12-inch (300-mm) intervals.
- B. Insulation Installation on Straight Pipes and Tubes:
1. Secure each layer of insulation to pipe with wire or bands, and tighten bands without deforming insulation materials.

2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with jackets with vapor retarder on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as that of pipe insulation. Where voids are difficult to fill with block insulation, fill the voids with a fibrous insulation material suitable for the specific operating temperature.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated insulation sections, or mitered or routed fittings, of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated insulation sections of same material as that of straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches (300 mm) o.c. and at end joints.

3.11 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless steel jackets.

3.12 FIELD QUALITY CONTROL

- A. Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- E. All insulation applications will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.13 PIPING INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.14 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation is one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.

- b. Mineral Wool, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.
 - B. Chilled Water (30% PG) and Brine, Above 40 Deg F (5 Deg C):
 - 1. NPS 12 (DN 300) and Smaller: Insulation is one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches (50 mm) thick.
 - c. Phenolic: 2 inches (50 mm) thick.
 - C. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. NPS 12 (DN 300) and Smaller: Insulation is one of the following:
 - a. Cellular Glass: 2 inches (50 mm) thick.
 - b. Mineral Wool, Preformed Pipe, Type II: 2 inches (50 mm) thick.
 - c. Phenolic: 2 inches (50 mm) thick.
 - D. Steam and Steam Condensate, Boiler Blowdown, Vents, Drains, and Safety Relief Vents 350 Deg F (177 Deg C) and Below:
 - 1. NPS 3/4 (DN 20) and Smaller: Insulation is one of the following:
 - a. Calcium Silicate: 2 inches (50 mm) thick.
 - b. Mineral Wool, Preformed Pipe Insulation, Type II: 2 inches (50 mm) thick.
 - 2. NPS 1 (DN 25) and Larger: Insulation is one of the following:
 - a. Calcium Silicate: 3 inches (75 mm) thick.
 - b. Mineral Wool, Pipe and Tank Insulation: 4 inches (100 mm) thick.
 - E. Heat-Recovery Piping:
 - 1. All Pipe Sizes: Insulation is one of the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - b. Mineral Wool, Preformed Pipe Insulation, Type II or Pipe and Tank Insulation: 1 inch (25 mm) thick.
- 3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
- A. Chilled Water and Brine:
 - 1. All Pipe Sizes: Insulation is one of the following:
 - a. Phenolic: 2 inches (50 mm) thick.
 - B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. All Pipe Sizes: Insulation is one of the following:
 - a. Phenolic: 2 inches (50 mm) thick.
- 3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE
- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - B. If more than one material is listed, selection from materials listed is Contractor's option.
 - C. Piping, Concealed:
 - 1. None.
 - D. Piping, Exposed:
 - 1. None.

2. Aluminum, [Smooth][Corrugated][Stucco Embossed]: [0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)][0.032 inch (0.81 mm)][0.040 inch (1.0 mm)] thick.
3. Painted Aluminum, Smooth: 0.016 inch (0.41 mm) thick.
4. Stainless Steel, Type 304, Smooth No. 2B Finish: 0.010 inch (0.25 mm) thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 1. Stainless Steel, Type 304, Smooth No. 2B Finish: [0.010 inch (0.25 mm)][0.016 inch (0.41 mm)][0.020 inch (0.51 mm)][0.024 inch (0.61 mm)] thick.
- D. Piping, Exposed:
 1. Stainless Steel, Type 304, Smooth No. 2B Finish: 0.016 inch (0.41 mm) thick.

3.18 UNDERGROUND, FIELD-APPLIED INSULATION JACKET

- A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION

SECTION 23 0800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:
 - 1. Energy supply systems.
 - 2. Heat generation systems.
 - 3. Cooling generation systems.
 - 4. Central-station air-handling systems.
 - 5. Air, steam, and hydronic distribution systems.
 - 6. Heating and cooling terminal and unitary equipment.
 - 7. BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING.
 - 8. TAB verification.
- B. Related Requirements:
 - 1. Section 01 9113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 01 9113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 01 9113 "General Commissioning Requirements."
- D. IgCC: International Green Construction Code.
- E. CM : Construction Manager.
- F. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.
- G. TAB: Testing, adjusting, and balancing.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For BAS and HVAC testing technician.
- B. Construction Checklists:

1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 01 9113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 01 9113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
 2. Cx plan, including material, installation, and performance construction checklists for systems, assemblies, subsystems, equipment, and components relating to BAS and HVAC to be part of the Cx process and in accordance with requirements in Section 01 9113 "General Commissioning Requirements and ASHRAE 202."
- C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Div. 23 Subcontractor, provide the following:
1. Equipment/instrument identification number.
 2. Planned Cx application or use.
 3. Manufacturer, make, model, and serial number.
 4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
- 1.4 ADDITIONAL RESPONSIBILITIES
- A. Refer to Section 01 9113: Detailed Contractor responsibilities common to all Divisions are specified in Section 01 9113. The following are additional responsibilities or notable responsibilities specific to Division 23.
- B. Construction Phase
1. Provide skilled technicians qualified to perform the work required.
 2. Provide factory-trained and authorized technicians where required by the Contract Documents.
 3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer's application, installation and start-up information.
 4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
 5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere in this Section.
 6. Start-Up, test/adjust/balance, and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.

7. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 01 0900. Each task or item shall be indicated with the Party actually performing the task or procedure.
 8. TAB: As outlined in Section 23 0593. Specifically as it relates to Cx:
 - a. Attend Construction Phase Cx Kick-Off Meeting and Cx progress meetings beginning within 3 months of start of TAB work;
 - b. Submit TAB Plan as indicated above;
 - c. Meet with Cx team to review TAB procedures and documentation required;
 - d. Demonstrate TAB procedures for repetitive tasks (zone balancing, AHU adjusting) as called for by the CxA;
 - e. Participate in Action List dialogue;
 - f. Provide all documentation electronically.
 - g. Attend a meeting convened by the CxA to coordinate with the safety certifying agency. The point of the meeting will be to coordinate protocols and measurement approaches to ensure that devices such as fume hoods and biosafety cabinets will be set up to achieve certification.
 - h. On airflow tracking zones:
 - 1) Balance all outlets downstream of VAV terminal. Record final settings.
 - 2) Measure airflow at both minimum and maximum flow conditions and calibrate VAV flow signals at both extremes. Extremes of flow shall be established by putting the zone into full heating and full cooling and raising the fume hood sashes to the stop height and lowering them to the airfoil. Record all parameters and final flow coefficient. If only one flow coefficient is available and this does not permit setting the range to within specified tolerances, enter the flow coefficient as the average of the two required flow coefficients and report the deficiency in an Action Item.
 - 3) Measure and record supply air flow at flow extremes with reheat valves both open and closed as required above.
- C. Acceptance Phase
1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
 - a. Manipulate systems and equipment to facilitate Functional Performance Testing
 - b. Provide any specialized instrumentation necessary for Functional Performance Testing;
 - c. Manipulate BAS and other control systems to facilitate Functional Performance Testing.
 - d. Provide a TAB technician to work at the direction of CxA for up to 16 hours beyond assistance specified above.
 - e. Provide a BAS technician to work at the direction of CxA for up to 16 hours beyond assistance specified above.
 - f. Maintain trends and monitor the facility throughout the Endurance Period.
- D. Warranty Phase
1. Maintain record documentation of any configurations, setpoints, parameters, etc. that change throughout the Warranty Period.
 2. Provide representative for off-season testing as required by CxA.
 3. Respond to warranty issues as required by Division 01 and the General Conditions.

1.5 PIPING CLEANING, FLUSH, AND FILL PLAN

- A. Contractors shall provide a Piping Cleaning, Flush, and Fill Plan to the CxA that provides a descriptive narrative and supporting calculations of the means and methods that will be used to clean out, flush, and fill the piping systems.
- B. The Piping Cleaning, Flush, and Fill Plan shall incorporate and be inclusive of all requirements of individual Sections relating to piping and pipe cleaning and flushing. In addition to the requirements of any other related Section, this document shall consist of the following at a minimum for each individual hydronic loop:
1. Overview schematic diagram of each of the hydronic systems, showing individual flow components such as chillers, boilers, pumps, heat exchangers, cooling towers, control valves, and strainers.
 2. Narrative and illustration indicating the equipment that will either participate or be bypassed by fluid flow during the clean and flush process.
 3. For equipment to be bypassed, description of the means for providing the bypass, including the type, size, and length of hoses or piping to be used.
 4. Description of how flow is to be induced (permanent pumps, temporary pumps, etc.) and flow rates to be imposed during the flush process.
 5. Calculation of resultant flow velocities in various portions of the piping system, with specific identification of the minimum velocity sections of the piping loop. Velocities should generally be shown to be above a 7 feet-per-second minimum speed to provide for adequate capability to flush and carry debris through the system to the appropriate strainer or clean-out location.
 6. Description of cleaning methods and materials to be used to flush the system. Description shall include cleaning material and concentration, details of the cleaning process including duration of circulation and flushing intervals, criteria for determining a clean flush, and name and qualifications of cleaning or chemical treatment subcontractors to be used.
 7. Identification and discussion of any isolated sections or dead-legs that will be present, including means to provide cleaning and flushing for these sections.
 8. Details of the strainers to be used for the flush and clean process, as well as final strainers to be used after cleaning. Contractor shall clean all strainers prior to turning over the system for commissioning.
 9. If the cleaning and flushing process is to be phased in sections, details should be provided to clarify how clean sections will be protected as other sections are flushed.

1.6 TEMPORARY OPERATION AND CONDITIONING PLAN

- A. Contractor shall be allowed to use permanent building equipment to provide temporary conditioning ONLY upon the approval of the A/E, Owner, and the CxA. Approval for such will only be given upon acceptance of a detailed Temporary Operating and Conditioning Plan provided by the individually involved subcontractors and compiled by the Construction Manager. The Temporary Operating and Conditioning Plan shall consider/address the following at a minimum:
1. Contractor shall address how equipment will be maintained in good, clean condition. Specifically address:

- a. Temporary Filtering of Air: Air filters used for construction shall be as or more effective than those specified for permanent use. Contractor shall remove construction filters and replace with new filters prior to FPT. Filters shall be maintained and replaced at the specified final pressure drop. Contractor shall install a magnehelic gauge for visual indication of pressure drop as well as setting and adjusting the loaded filter DP switch for monitoring on the BAS.
 - b. Temporary Filtering of Water and Condensate: Construction strainers shall be used while circulating fluid during construction. Construction strainer shall be finer than that specified for final strainers.
 - c. Sealing/Filtering of Open Ducts: Address that all open ducts shall be either sealed or protected with filter media. Return or exhaust systems shall not be used during construction unless otherwise approved.
 - d. Lubrication and Maintenance: Contractor shall maintain the systems and equipment in accordance with the manufacturer's instructions. Contractor shall coordinate lubricants used with Owner's operators. Frequency of lubrication and inspection shall be as recommended by manufacturer's literature. Applicable maintenance lubrication schedules shall be included in the Plan. Draft maintenance logs shall be submitted with Plan and completed as maintenance is performed.
 - e. Operation Outside of Normal Ranges: Systems and equipment shall not be operated outside the range of specified conditions. The Temporary Conditioning Plan shall address how the Contractor will ensure that operation will not harm the equipment.
2. Emergency Condition Identification and Response Protocols: The Temporary Conditioning Plan shall address protocols for responding to equipment malfunctions and or harmful operation. Automatic safeties and remote enunciation shall be in place to protect people and property. Temporary operation shall not be allowed until there is an automatic communication/enunciation medium such as a phone connection or an Internet connection. At a minimum, an alarm on the equipment used for temporary service shall be automatically sent to the Contractor's 24 hour monitoring service and to the Owner's help desk. The Contractor shall respond to and be responsible for securing conditions within the building.
 3. Building Protection: Address how the system will be controlled to avoid humidity conditions that could either promote mold growth or cause corrosion.
 4. Equipment Reconditioning: Address with specific means and methods how the equipment used for temporary conditioning will be reconditioned to like-new condition. Belts, seals, bearings, couplings, or other parts that wear more than 3% of their expected life shall be replaced.
 5. Cleaning: Address how ducts, pipes, coils, converters, air handling equipment, terminal units, etc. shall be cleaned prior to Turn-Over.
 6. Operations Log: Contractor responsible for operating the equipment shall maintain a log of all activities associated with operating and maintaining equipment. Log shall be submitted to Owner on a frequency specified by the Owner.
 7. Operating System Alterations: The Temporary Conditioning Plan shall address specific protocol for doing work on the systems.
 8. Damages: Any material, device, component, or equipment that is assessed as damaged or as having a substantially shortened life as a result of temporary conditioning operation shall be replaced by the Contractor at no cost to the Owner or to the project.

9. Segregation: Where only portions of a system are to be used, Contractor shall specifically indicate how the used portion will be isolated from the unused portion. The Temporary Conditioning Plan shall address how to ensure that the reduced operation condition will be maintained within acceptable ranges, and/or how capacity will be throttled to keep all operating parameters in recommended ranges.

1.7 QUALITY ASSURANCE

- A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:
 1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
 3. International Society of Automation (ISA)-Certified Control Systems Technician (CCST) Level I.
- B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
 2. Minimum three years' experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.
- C. Testing Equipment and Instrumentation Quality and Calibration:
 1. Capable of testing and measuring performance within the specified acceptance criteria.
 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- D. Proprietary Test Instrumentation and Tools:
 1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 2. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS:

- A. Perform Cx process in accordance with Section 01 9113 "General Commissioning Requirements" for BAS and HVAC and in accordance with the following:
 - 1. Commissioning standards acceptable to the authority having jurisdiction.

3.2 CONSTRUCTION CHECKLISTS

- A. Preliminary detailed construction checklists are to be prepared under Section 01 9113 "General Commissioning Requirements" for each BAS and HVAC system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in IgCC and ASHRAE 202. Contractor performs the following:
 - 1. Review BAS and HVAC preliminary construction checklists and provide written comments on checklist items where appropriate.
 - 2. Return preliminary Construction Checklist with review comments within 10 days of receipt.
 - 3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 4. Use only construction checklists marked "Approved for Use, (date)" When performing tests. Mark construction checklists in the appropriate place as indicated Project events are completed, and provide pertinent details and other information.
- B. Prepare preliminary detailed construction checklists for each BAS and HVAC system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in IgCC and ASHRAE 202.
 - 1. Submit preliminary construction checklists to CxA and Designer for review.
 - 2. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 3. Use only construction checklists, marked "Approved for Use, (date)" when performing tests. Mark construction checklists in the appropriate place, as indicated Project events are completed and provide pertinent details and other information.
- C. Systems required to be commissioned under IgCC:
 - 1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and/or passive) and associated controls.
 - 2. Air-curtain systems.
 - 3. Water-pumping and -mixing systems over 5 hp (4 kW) and purification systems.
 - 4. Energy and building management and demand-control systems.
- D. Additional systems required to be commissioned:
 - 1. Energy supply systems, including the following:
 - a. Fuel gas supply.
 - b. Central-plant hot-water supply.
 - c. Demand-control systems.
 - 2. Heat generation systems, including the following:

- a. Boilers.
 - b. Furnaces.
 - c. Fuel-fired unit heaters.
 - d. Auxiliary equipment.
3. Cooling generation systems, including the following:
 - a. Water chillers.
 - b. Direct-expansion refrigeration systems.
4. Air-handling systems, including the following:
 - a. Supply, return, and exhaust air fans, motors, and drives.
 - b. Automatic and gravity dampers.
 - c. Heating and cooling devices.
 - d. Humidification and dehumidification devices.
 - e. Air filters.
 - f. Hangers and supports.
 - g. Interlock between air-handling system and fire/smoke alarm system.
5. Air duct systems, including the following:
 - a. Duct systems.
 - b. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
 - c. Duct-mounted access doors and panels.
 - d. Hangers and supports.
6. Air curtain systems.
 - a. Supply air fans and motors.
 - b. Heating and cooling devices.
7. Steam and hydronic distribution systems, including the following:
 - a. Steam distribution piping systems.
 - b. Condensate piping systems, including condensate pumps and all accessories.
 - c. Hydronic piping systems and all accessories.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
 - g. Heat tracing.
8. Refrigerant piping, including the following:
 - a. Refrigerant piping, fittings, and specialties.
 - b. Refrigerant charge.
 - c. Sleeves and sleeve seals.
 - d. Meters and gauges.
 - e. General-duty and specialty valves.
 - f. Hangers and supports.
9. Smoke-control systems, including the following:
 - a. Exhaust and makeup fans, motors, and drives.
 - b. Exhaust and makeup air distribution systems.
 - c. Smoke dampers.
 - d. Smoke detectors.
 - e. Fire and smoke alarm system interface.
10. Heating and cooling terminal and unitary equipment, including the following:
 - a. Unit ventilators.
 - b. Unit heaters.
 - c. Fan-coil units.
 - d. Electric heating.
 - e. Unitary heating and cooling equipment.

11. Vibration isolation systems.
12. Controls and instrumentation, including the following:
 - a. Energy monitoring and recording system.
 - b. Controllers and sensors.
 - c. Automatic control valves, dampers, and actuators.
 - d. Control interface with fans, pumps, dampers, and other equipment and systems.
 - e. Demand-control systems.
13. TAB Verification:
 - a. Airflow.
 - b. Water flow.
 - c. Space pressurization.
14. Documentation:
 - a. Mechanical systems manuals.
 - b. Documentation of required commissioning.
15. Mechanical insulation, including the following:
 - a. Duct and plenum insulation.
 - b. HVAC piping insulation.

3.3 Cx TESTING PREPARATION

- A. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and all systems are set to and maintaining set points as required by the design documents.
- C. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.

- B. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.
- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation, and schedule seasonal tests.

3.5 Cx TESTS COMMON TO HVAC SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

3.6 CONSTRUCTION CHECKLIST EXAMPLES

- A. Vibration Isolation in HVAC Systems:
 - 1. Prerequisites: Acceptance of results of construction checklists for vibration control devices specified in Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment".
 - 2. Components to Be Tested:
 - a. Vibration isolation control devices in HVAC systems.
 - b. Support systems.
 - 3. Test Purpose: Evaluate effectiveness of vibration isolation control devices.
 - 4. Test Conditions, Constant Speed Equipment: Measure vibration of the facility structure at three locations designated by Owner's witness while the isolated equipment operates.
 - 5. Test Conditions, Variable Speed Equipment: Measure vibration of the facility structure at three locations designated by Owner's witness at the following operating conditions:
 - a. Maximum speed.
 - b. Minimum speed.
 - c. Critical speed.
 - 6. Acceptance Criteria: Structure-borne vibration not to exceed specified performance.
- B. Heat Tracing in HVAC Systems:

1. Prerequisites: Acceptance of results of construction checklists for heat tracing specified in HVAC systems. Comply with requirements listed in Section 23 0533 "Heat Tracing for HVAC Piping."
2. Equipment and Systems to Be Tested:
 - a. Self-regulating, parallel-resistance heating cables.
 - b. Heat tracing circuit controller.
3. Test Purpose:
 - a. Evaluate response to ambient temperature below freeze-protection set point.
 - b. Evaluate heating cable fault alarm.
4. Test Conditions:
 - a. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) above freeze-protection set point of 30% propylene glycol (initial set point 41 deg F (5 deg C) 22 deg F (-14 deg C)). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is energized.
 - b. Subject temperature sensor to temperature approximately 3 deg F (2 deg C) below freeze-protection set point of 30% propylene glycol (initial set point 41 deg F (5 deg C)). Monitor sensed temperature with a calibration-grade thermometer. Gradually change set point or sensed temperature until freeze-protection circuit is de-energized.
 - c. Simulate an electrical fault on the heating cable.
5. Acceptance Criteria:
 - a. Freeze-protection circuit is energized at set-point temperature of minus 2 deg F (1 deg C).
 - b. Freeze-protection circuit is de-energized at set-point temperature of plus 2 deg F (1 deg C).
 - c. Heater trace circuit controller initiates an alarm of cable fault. Alarm is correctly reported at the alarm panel.

3.7 TAB VERIFICATION

- A. Prerequisites: Completion of "Examination" Article requirements and correction of deficiencies, as specified in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
- B. Completion of "Preparation" Article requirements for preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
- C. Scope: HVAC air systems and hydronic piping systems.
- D. Purpose: Differential flow relationships intended to maintain air and water pressurization differentials between the various areas of Project.
- E. Conditions of the Test:
 1. Cx Test Demonstration Sampling Rate: As specified in "Inspections" Article in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
 2. Systems operating in full heating mode with minimum outside-air volume.
 3. Systems operating in full cooling mode with minimum outside-air volume.
 4. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.

F. Acceptance Criteria:

1. Under all conditions, rechecked measurements comply with "Inspections" Article in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."
2. Additionally, no rechecked measurement shall differ from measurements documented in the final report by more than the tolerances allowed.
3. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.8 HEATING CONTROL SYSTEM Cx TESTS

- A. Test all sequences of operation as shown on the controls drawings.

3.9 CHILLER SYSTEM Cx TESTS

- A. Test all sequences of operation as shown on the controls drawings.

3.10 TERMINAL UNIT EQUIPMENT Cx TESTS

- A. Test all sequences of operation as shown on the controls drawings.

3.11 AIR-HANDLING SYSTEM Cx TESTS

- A. Test all sequences of operation as shown on the controls drawings.

3.12 BUILDING AUTOMATION SYSTEM (BAS) COMMISSIONING

A. WORK INCLUDED

1. BAS Start-Up and Functional Performance Testing.
2. Validation of proper and thorough installation of BAS and associated equipment.
3. Generic Start-Up Documentation for BAS.
4. Development of final Start-Up Documentation for BAS.
5. Functional Performance Testing of BAS.
6. Coordination of BAS-related training.
7. Documentation of BAS Operation and Maintenance Documentation.

B. GENERAL DESCRIPTION

1. This section defines responsibilities of the Building Automation System Contractor to commission the BAS.
2. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner's operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.
3. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing.

4. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.
- C. SCOPE
1. The scope of Commissioning on this project shall include the entire BAS system.
- D. DEFINITIONS AND ABBREVIATIONS
1. Refer to Section 01 9113 for a complete list of Definitions and Abbreviations.
 2. POT (Portable Operators Terminal): Portable operator workstation (typically a laptop computer) that has BAS software loaded and the capability to access, program, and edit the BAS.
 3. HHD (Hand-Held Device): Portable device (typically with limited functionality) that is used to access components of the BAS. May be a standard PDA or proprietary device/interface.
- E. CONTRACTOR RESPONSIBILITIES
1. General responsibilities of the BAS Contractor (BAC) are specified in Section 01 9113. The following indicate additional specific responsibilities of the BAS Contractor.
 2. Assist CxA in verification and Functional Performance Testing. Assistance will typically include the following:
 - a. Establish trend logs of system operation as specified herein.
 - b. Manipulate systems and equipment to facilitate Functional Performance Testing. Typically, this will only be for initial samples of like systems.
 - c. Provide POTs or operator workstations in locations convenient to testing activities as specified below.
 - d. Provide CxA with appropriate passwords, keys, and access to control panels and workstations.
 - e. Where control systems do not allow a test mode or the overriding of physical input values for testing, program an interim virtual point for all inputs that can be used to represent the point and be overridden for testing.
 3. Provide a control technician to work at the direction of the CxA for software optimization assistance for a minimum of 40 hours during the Acceptance Phase of the project.
 4. Controls Parameter Matrix: Contractor shall provide a form summarizing all setpoints and alarm parameters and alarming strategies for the Owner to complete. Organize a meeting to discuss the desired initial setpoints and alarm parameters. Contractor shall enter the requested setpoints and alarm parameters at completion of start-up and record the applicable settings in the Start-Up Documentation.
 5. Final Systems Operation Training: The BAC shall train the Owner and Operators on whole-building operation and use of the BAS. This training shall focus primarily on BAS control of building systems and operation and its impact on building performance, and shall be conducted after Functional Completion. Additional information is provided in Section 01 9113.
- F. INSTRUMENTATION
1. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. If not otherwise noted, the following minimum requirements apply:

- a. Temperature sensors and digital thermometers shall have a certified calibration within the past year and a resolution of $\pm 0.1^{\circ}\text{F}$.
- b. Pressure sensors shall have an accuracy of $\pm 2.0\%$ of the value range being measured (not full range of meter) and have been calibrated within the last year.
- c. All equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.
2. Standard Testing Instrumentation: Standard instrumentation used for testing air and water flows, temperatures, humidity, noise levels, amperage, voltage, and pressure differential in air and water systems related to functional testing shall be provided by CxA.
3. Special Tools: Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and turned over to the Owner upon project completion.

G. TAB & COMMISSIONING Portable operators terminal

1. Provide the CxA with all software, connection devices, licenses, passwords, etc. to facilitate connection to the BAS throughout the building. Provide a license to graphic software, and all operating software necessary for testing and configuration of all control elements at all levels. License may be a temporary license that will expire after the completion of the Warranty Period. Options include:
 - a. A laptop computer provided by BAS Contractor for dedicated use by the CxA throughout the Construction and Acceptance Phases. This would be turned over to the Owner at the end of the Acceptance Phase.
 - b. Browser access to the full graphic software: CxA will provide laptop, however BAS Contractor shall set up the laptop to successfully connect.
 - c. Licensed client software to be installed on CxA computer: BAS Contractor shall install the software and ensure it is functional.
 - d. Terminal Services session access to a graphic server with required CALs to allow use of all required software. BAS Contractor shall configure the CxA computer to connect to the terminal session.
2. Access to the BAS must be provided throughout the building as more fully defined as follows:
 - a. Full wireless connection to the graphic server throughout the building will be adequate.
 - b. Network connection for full access to the graphic server within 50' of any point in the building.
 - c. Exception to 1 and 2 above: An acceptable alternative to full building access to the graphic server relating to terminal controls shall be providing to the CxA the devices and software required to connect to local terminal controllers through a connection port in the space such as connection to a jack on the temperature sensor (basically what is required by TAB specified below). This does not apply to mechanical rooms as full graphic access is required in mechanical rooms.
3. Provide software required by TAB to calibrate all flow sensors. TAB will provide computer to be used as a portable operator's terminal. Any manufacturer specific hardware such as connection cables, converters, hand held devices, etc. shall be provided by the BAS Contractor.
4. Connections shall be provided local to the device being calibrated. For instance, for VAV boxes, connection of the operator's terminal shall be either at the sensor as well as at the box. Otherwise a wireless system shall be provided to facilitate this local functionality.

H. BAS Start-Up TESTING, ADJUSTING, CALIBRATION

1. BAS work and/or systems shall be fully functioning prior to Demonstration and Acceptance Phase. Contractor shall start, test, adjust, and calibrate all work and/or systems under this contract, as described below:
 - a. Inspect the installation of all devices. Review the manufacturer's installation instructions and validate that the device is installed in accordance with them.
 - b. Verify proper electrical voltages and amperages, and verify that all circuits are free from faults.
 - c. Verify integrity/safety of all electrical connections.
 - d. Coordinate with TAB Contractor to obtain and with CxA to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB Contractor, and note any TAB deficiencies in the BAS Start-Up Documentation:
 - 1) Optimum duct static pressure setpoints for VAV air handling units.
 - 2) Minimum outside air damper settings for air handling units.
 - 3) Optimum differential pressure setpoints for variable speed pumping systems.
 - 4) Calibration parameters for flow control devices such as VAV boxes and flow measuring stations. BAS Contractor shall provide hand held device as a minimum to the TAB and CxA to facilitate calibration. Connection for any given device shall be local to the device (i.e., at the VAV box or at the thermostat). HHD or POT shall allow querying and editing of parameters required for proper calibration and Start-Up.
 - 5) Calibration parameters for fume hoods.
 - e. Test, calibrate, and set all digital and analog sensing and actuating devices. Calibrate each instrumentation device by making a comparison between the BAS display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range). Record the measured value and displayed value for each device in the BAS Start-Up Documentation.
 - f. Check and set zero and span adjustments for all transducers and transmitters.
 - g. For dampers and valves:
 - 1) Check for adequate installation including free travel throughout range and adequate seal.
 - 2) Where control loops are sequenced, check for proper control without overlap
 - h. For actuators:
 - 1) Check to insure that device seals tightly when the appropriate signal is applied to the operator.
 - 2) Check for appropriate fail position, and that the stroke and range is as required and coordinated with the programmed ranges when it is operating under normal conditions.
 - 3) For pneumatic operators, adjust the operator spring compression as required to achieve close off. If positioner or volume booster is installed on the operator, calibrate per manufacturer's procedure to achieve spring range indicated. Check split range positioners to verify proper operation. Record settings for each device.
 - 4) Check the stroke and range under actual loading conditions and validate that they correlate with programmed values.

- 5) For sequenced electronic actuators, calibrate per manufacturer's instructions to required ranges.
- i. Check each digital control point by making a comparison between the control command at the CU and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the OI display. Record the results for each device.
- j. For outputs to reset other manufacturers devices (such as VSDs) and feedback from them, calibrate ranges to establish proper parameters. Coordinate with representative of the respective manufacturer and obtain their approval of the installation.
- k. Verify proper sequences by using the approved Start-Up Documentation to record results. Verify proper sequence and operation of all specified functions.
- l. Verify that all safety devices trip at appropriate conditions. Adjust setpoints accordingly.
- m. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Record tuning parameters and response test results for each control loop in the BAS Start-Up Documentation. Except from a start-up, maximum allowable variance from setpoint for controlled variables under normal load fluctuations shall be as follows. Within 3 minutes of any step-change (for which the system has the capability to respond) in the control loop, the following tolerances shall be maintained (exceptions noted):
 - 1) Duct air temperature: ± 1 deg F
 - 2) Zone temperature: $\pm 3^{\circ}\text{F}$ within 3 minutes and control within ± 2 deg F
 - 3) Chilled water temperatures: ± 1 deg F
 - 4) Hot water temperatures: ± 2 deg F
 - 5) Duct air pressure: ± 0.25 i.w.g
 - 6) Water pressure: ± 1 psig
 - 7) Duct relative humidity: $\pm 3\%$ when adding humidity
 - 8) Zone relative humidity: $\pm 5\%$ when adding humidity
 - 9) Terminal air flow control: $\pm 5\%$ of setpoint. This includes all VAV terminal control and exhausted BSCs, canopy hoods, ventilated cage racks, necropsy tables, and other scientific equipment with supply or exhaust ventilation.
 - 10) Zone pressurization (on active control systems): ± 0.03 i.w.c. with no door or window movements. No high containment space shall go more than 0.15 i.w.c. positive, nor go positive at all for more than 20 seconds.
- n. For communication interfaces and BAS control panels:
 - 1) Ensure devices are properly installed with adequate clearance for maintenance and with clear labels in accordance with the record drawings.
 - 2) Ensure that terminations are safe, secure and labeled in accordance with the record drawings.
 - 3) Check power supplies for proper voltage ranges and loading.
 - 4) Ensure that wiring and tubing are run in a neat and workman-like manner, either bound or enclosed in trough.
 - 5) Check for adequate signal strength and acceptable bandwidth utilization on communication networks.
 - 6) Check for stand-alone performance of controllers by disconnecting the controller from the LAN. Verify the event is annunciated at Operator Interfaces. Verify that the controlling LAN reconfigures as specified in the event of a LAN disconnection.
 - 7) Ensure that all outputs and devices fail to their proper positions/states.

- 8) Ensure that buffered and/or volatile information is retained through power outage.
- 9) With all system and communications operating normally and all trends functioning, sample and record update/annunciation times for critical alarms fed from the panel to the Operator Interface.
- 10) Check for adequate grounding of all BAS panels and devices.
- 11) Run self diagnostic routines and ensure they are functional.
- 12) Check the memory allocation and loading to ensure adequate and excess capacity is available and that it will not affect control functionality.
- o. Coordinate desired initial alarm strategies with Owner's Operators. Set all required alarms and document the initial settings in the Start-Up Documentation.
- p. Coordinate all initial setpoints with Owner's Operators. Ensure those setpoints are active.
- q. For Operator Interfaces:
 - 1) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.
 - 2) Output all specified BAS reports for review and approval.
 - 3) Verify that the alarm printing and logging is functional and per requirements.
 - 4) Verify that trend archiving to disk and provide a sample to the CxA for review.
 - 5) Verify alarm enunciation functionality. Time delay from actual occurrence to the time updated or enunciated on the screen. Ensure it is per the specified requirements.
 - 6) Verify that real time and historical trends are accessible and viewable in graph format.
 - 7) Verify that paging/dial out alarm annunciation is functional.
 - 8) Verify the functionality of remote OIs and that a robust connection can be established consistently.
 - 9) Verify that required third party software applications required with the bid are installed and are functional.
 - 10) Demonstrate open protocol and custom third party interfaces reliably communicate and check response time.
 - 11) Verify response times and screen update and refresh times are per the requirements.
 - 12) Verify that all custom programs are editable from the OI. Check upload, download, back up and restore capabilities of system configuration information as well as custom programs.
 - 13) Verify schedules are set up and working.
 - 14) Verify Owner stipulated security and permissions is set up and functional.
 - 15) In concert with the Building Power Outage test, validate that critical GUI installations are properly powered by UPS and emergency outlets to keep it functional during a power outage. Validate that the space has adequate lighting to manage the building in the event of an outage.
- r. Start-up and check out control air compressors and air drying and filtering systems in accordance with the appropriate section and with manufacturer's instructions.
 - 1) Validate adequate drying and pressures.
 - 2) Validate adequate redundancy
 - 3) Validate max run time and cycle time vs manufacturer's recommendations

- 4) Validate that routing of the compressed air does not result in condensation at any point in the system when used with the specified drier.
 - 5) Check all PRVs both primary and back up to ensure adequate functionality and maintenance of downstream pressure.
- s. Verify proper interface with Fire Alarm System.
- t. Verify proper interface with control panels of equipment with self-contained controls that are being monitored by the BAS.
2. Submit Start-Up Documentation. This shall be completed, submitted, and approved prior to demonstration and Acceptance Phase.

I. SENSOR CHECKOUT AND CALIBRATION

1. General Checkout: Verify that all sensor locations are appropriate and are away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading of each other for pressure. Tolerances for critical applications may be tighter.
2. Calibration: Calibrate all sensors using one of the following procedures:
 - a. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor at various points across the range. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified for the sensor. If not, adjust offset and range, or replace sensor. Where sensors are subject to wide variations in the sensed variable, calibrate sensor within the highest and lowest 20% of the expected range.
 - b. Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the OI. Record all values and recalibrate controller as necessary to conform to tolerances. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or BAS) is within the tolerances specified. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
3. Sensor Tolerance: Sensors shall be within the tolerances specified for the device. Refer to Section 23 0900.

J. LOOP TUNING

1. For all control loops, Contractor shall tune the loops to ensure the fastest stable response without hunting, offset or overshoot with tolerances defined above. Contractor shall introduce upsets to the load when possible to affect response. Otherwise, setpoints can be changed to affect the response.
2. Generally tune loops during periods of high gain.
3. Document all parameters either by capturing text, short interval trends, or screen shots of trend graph documenting the final response.

K. COIL VALVE LEAK CHECK

1. Verify proper close off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the OI, command the valve to close. Energize fans. After 5 minutes, observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.
- L. VALVE STROKE SETUP AND CHECK
1. For all valve and actuator positions checked, verify the actual position against the OI readout.
 2. Set pumps to normal operating mode. Command valve closed, verify that valve is closed, and adjust output zero signal as required. Command valve open, verify position is full open and adjust output signal as required. Command valve to a few intermediate positions. If actual valve position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
- M. GRAPHIC COORDINATION
1. The Contractor shall prepare all graphics (only one example graphic is required for typical systems like terminal units) with points embedded for review of CxA and Owner. Owner shall use these graphics to provide direction to Contractor for the required final graphic. All final graphics must be complete and active before functional testing. Any deviation from the approved graphics will be considered a failure from the perspective of the functional test.
- N. BAS DEMONSTRATION
1. Demonstrate the operation of the BAS hardware, software, and all related components and systems to the satisfaction of the CxA and Owner. Schedule the demonstration with the Owner's representative 1 week in advance. Demonstration shall not be scheduled until all hardware and software submittals, and the Start-Up Test Report are approved.
 2. The Contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, instruments, ladders, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific hardware, software, and the HVAC systems. All training documentation and submittals shall be at the job site.
 3. Demonstration shall typically involve small representative samples of systems/equipment randomly selected by the Owner and CxA.
 4. The system shall be demonstrated following the same procedures used in the Start-Up Test by using the approved Commissioning Checklists. Demonstration shall include, but not necessarily be limited to, the following:
 - a. Demonstrate that required software is installed on BAS workstations. Demonstrate that graphic screens, alarms, trends, and reports are installed as submitted and approved.
 - b. Demonstrate that points specified and shown can be interrogated and/or commanded (as applicable) from all workstations, as specified.
 - c. Demonstrate that remote dial-up communication abilities are in accordance with these Specifications.

- d. Demonstrate correct calibration of input/output devices using the same methods specified for the start-Up tests. A maximum of 10 percent of I/O points shall be selected at random by CxA and/or Owner for demonstration. Upon failure of any device to meet the specified end-to-end accuracy, an additional 10 percent of I/O points shall be selected at random by CxA for demonstration. This process shall be repeated until 100 percent of randomly selected I/O points have been demonstrated to meet specified end-to-end accuracy.
 - e. Demonstrate that all BAS and other software programs exist at respective field panels. The BAS programming and point database shall be as submitted and approved.
 - f. Demonstrate that all BAS programs accomplish the specified sequences of operation.
 - g. Demonstrate that the panels automatically recover from power failures, as specified.
 - h. Demonstrate that the stand-alone operation of panels meets the requirements of these Specifications. Demonstrate that the panels' response to LAN communication failures meets the requirements of these Specifications.
 - i. Identify access to equipment selected by CxA. Demonstrate that access is sufficient to perform required maintenance.
 - j. Demonstrate that required trend graphs and trend logs are set up per the requirements. Provide a sample of the data archive. Indicate the file names and locations.
5. BAS Demonstration shall be completed and approved prior to Functional Performance Testing. CxA shall determine if the system is ready for Functional Performance Testing and document any problems requiring Contractor attention.
- a. If the systems are not ready for Functional Performance Testing, Contractor shall correct problems and provide notification to the Owner's representative that all problems have been corrected. The Acceptance Period shall be restarted at a mutually scheduled time for an additional one week period. This process shall be repeated until CxA issues notice that the BAS is ready for Functional Performance Testing.
6. Any tests successfully completed during the BAS Demonstration will be recorded as Passed for the Functional Performance Testing and will not have to be re-accomplished.

O. FUNCTIONAL PERFORMANCE TESTING

- 1. Requirements for assistance with Functional Performance Testing are specified in the Section 01 9113, Section 23 0800 and Section 26 0800. Provide assistance during Functional Performance Testing per the Section 01 9113 and related Specifications.

P. BAS ACCEPTANCE PHASE AND OBSERVATION PERIOD

- 1. BAS Acceptance Phase: BAS Acceptance Phase consists of the Functional Performance Testing process of the BAS by the CxA and shall begin after approval of the BAS Demonstration and prior to issuance of Substantial Completion. Acceptance Phase for the BAS shall not be scheduled until all HVAC systems are in operation, the Start-Up Documentation has been reviewed, all required cleaning and lubrication has been completed (i.e., filters changed, piping flushed, strainers cleaned, etc.), and TAB report has been submitted and approved. Acceptance Phase and its approval to begin will be performed on a system-by-system basis if mutually agreed upon by Contractor and Owner.

2. BAS Observation Period: After Functional Performance Testing, the BAS shall be shown to operate properly for 2 weeks without malfunction, without alarm caused by control action or device failure, and with smooth and stable control of systems and equipment in conformance with these specifications. At the end of the two weeks, BAS Contractor shall forward the trend logs to the CxA for review.
3. During the Acceptance Phase, the Contractor shall maintain a hard copy log of all alarms generated by the BAS. For each alarm received, Contractor shall diagnose the cause of the alarm, and shall list on the log for each alarm, the diagnosed cause of the alarm, and the corrective action taken. If in the Contractor's opinion, the cause of the alarm is not the responsibility of the Contractor, Contractor shall immediately notify the Owner's representative.
4. During the Acceptance Phase, the Contractor shall maintain all controller network and workstation hardware and software in a state that will allow remote access by CxA to trend logs as specified below.

Q. BAS TREND REQUIREMENTS

1. The BAS Contractor shall configure and analyze all trends required under this Section.
2. Trends are historical archives on computer disks that document the operation of the systems and equipment. Trends can be time-series (interval) recordings of system I/O parameters or change-of-value (COV) based trends that record when a system value changes by more than a specified threshold.
3. CxA will analyze trend logs of the system operating parameters to evaluate normal system functionality. The requirements of the trending are specified below. Contractor shall establish these trends, ensure they are being stored properly, and forward the data in electronic format to the CxA.
4. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same time intervals and be presented in a maximum of two separate two dimensional formats with time being the vertical axis and field name being the horizontal axis.. Data shall be forwarded in one of the following formats.
 - a. Microsoft Access Database (.mdb)
 - b. Microsoft Excel Spreadsheet (.xls)
 - c. Comma Separated Value (.csv or .txt), preferably with quotes delimiting text fields and # delimiting date/time fields.
5. Sample times indicated as COV ($\pm$) mean that the changed parameter only needs to be recorded whenever the value changes by the amount listed. When output to the trend file, the latest recorded value shall be listed along with the time increment record. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the time interval common to other point trends for the system.
6. Contractor shall provide the CxA with required passwords, phone numbers, etc. to allow the CxA access to the trend log data and allow downloading to a remote location. Contractor shall also provide step-by-step written instructions for accessing the data.
7. Trending Requirements: All I/O points on primary equipment shall be trended throughout the Cx process on 10 min. intervals for analog values and change-of-value for binary values. Trends shall include but are not necessarily limited to the following points:
 - a. Outside air temperature
 - b. Outside air relative humidity
 - c. Outside air enthalpy
 - d. Cooling tons

- e. All sensed hydronic temperatures
- f. All sensed air temperatures and relative humidity measurements on primary equipment
- g. All damper outputs on primary equipment
- h. All valve outputs on primary equipment
- i. All sensed fan volumes (flow) on primary equipment
- j. All inputs and outputs to Variable Speed Drives
- k. Return (or exhaust) air temperature on each air handler
- l. All safety indications
- m. Status on all primary equipment
- n. All air and water pressures on primary equipment or systems
- o. Zone temperatures
- p. Steam flow
- q. Electricity consumption where monitored.
- r. Natural gas flows
- s. Converter steam valves and hot water temperatures
- t. Steam supply pressures and temperatures.
- u. All points on primary equipment and selected sampling of terminal points unless approved otherwise.

R. TREND GRAPHS

- 1. Trend graphs shall be used during Functional Performance Testing to facilitate and document testing. Contractor shall prepare controller and workstation software to display graphical format trends throughout the Acceptance Phase. Trend graphs shall demonstrate compliance with contract documents. Trended values and intervals shall be the same as those specified for the Functional Performance Tests.
- 2. Lines shall be labeled and shall be distinguishable from each other by using either different line types or different line colors.
- 3. Indicate engineering units of the y-axis values; e.g. degrees F., inches w.c., Btu/lb, percent wide open, etc.
- 4. The y-axis scale shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.
- 5. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended.
- 6. All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended simultaneously and on a common trend period.
- 7. Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
- 8. The format of all trend graphs must be provided as approved by the CxA.

S. WARRANTY PHASE - OPPOSITE SEASON TRENDING AND TESTING

- 1. Trending: Throughout the Warranty Phase, trend logs shall be maintained as required for the Acceptance Phase. BAS Contractor shall forward archived trend logs to the CxA for review upon CxA request. CxA will review these and notify BAS Contractor of any warranty work required.
- 2. Opposite Season Testing: Within 6 months of completion of the Acceptance Phase, CxA shall schedule and conduct Opposite Season Functional Performance Testing. The BAS Contractor shall support this testing and remedy any deficiencies identified.

T. SOFTWARE OPTIMIZATION ASSISTANCE

1. The Contractor shall provide the services of a BAS technician as specified above at the project site to be at the disposal of the CxA. The purpose of this requirement is to make changes, enhancements and additions to control unit and/or workstation software that have been identified by the CxA during the construction and commissioning of the project and that are beyond the specified Contract requirements. The cost for this service shall be included with the bid. Requests for assistance shall be for contiguous or non-contiguous 8-hour days, unless otherwise mutually agreed upon by Contractor, CxA, and Owner. The Owner's representative shall notify Contractor 2 days in advance of each day of requested assistance.
2. The BAS technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the BAS technician provided cannot perform every software task requested by the CxA in a timely fashion, Contractor shall provide additional qualified personnel at the project site as requested by the CxA to meet the total specified requirement on-site.

U. BAS OPERATOR TRAINING

1. Provide up to 6 complete sets of User Manuals (hard copy and one electronic copy) to be used for training.
2. BAS Contractor shall submit a Training Plan per the requirements of Div 01 to the CM who will forward it to the A/E and CxA for review.
3. On Site Training: Provide services of BAS Contractor's qualified technical personnel to instruct Owners personnel in operation and maintenance of the BAS. Instruction shall be in classroom setting at the project site for appropriate portions of the training. Training may be in non-contiguous days at the request of the Owner. The Owner's representative shall notify Contractor 1-week in advance of each day of requested training. The Contractor's designated training personnel shall meet with the A/E, CxA and Owner's representative for the purpose of discussing and fine-tuning the training agenda prior to the first training session. Training agenda shall be as follows:
 - a. Basic Operator Workstation Training:
 - 1) Brief walk-through of building, including identification of all controlled equipment and condensed demonstration of controller portable and built-in operator interface device display capabilities.
 - 2) Brief overview of the various parts of the BAS O&M manuals, including hardware and software programming and operating publications, catalog data, controls installation drawings, and BAS programming documentation.
 - 3) Demonstration of workstation login/logout procedures, password setup, and exception reporting.
 - 4) Demonstration of workstation menu penetration and broad overview of the various workstation features.
 - 5) Overview of systems installed.
 - 6) Present all site-specific naming conventions and points lists, open protocol information, configuration databases, back up sequences, upload/download procedures etc.
 - 7) Overview of scheduling procedures.
 - 8) Overview of alarm features, including how to acknowledge, respond to, and archive alarms, and how to access further information from them.
 - 9) Overview of trend features, including how to set up and view trends.
 - 10) Overview of workstation reporting features and introductory level report generation and scheduling.
 - b. BAS Technician Training:

- 1) General review of sequence of operation and control logic for the project site, including standalone and fail safe modes of operation
- 2) Uploading/downloading and backing up controller configuration and application programs
- 3) Review of installed components including all communication devices, controllers, I/O, etc., and how to install/replace, maintain, commission, and diagnose them
- 4) Introduction to controller programming and overview of the programming application interface
- 5) Defining trends, generating graphs in real time; archiving trends, accessing historical archive and generating reports from them
- 6) Introductory network administration
- 7) Introduction to creating and editing graphics
- 8) Review of setpoint optimization and fine-tuning concepts
- 9) OI use and maintenance
- 10) Web page creation as applicable
- c. System Administrator Training:
 - 1) Overview of system architecture including all routers, bridges, repeaters, gateways, communications protocols, servers, controllers etc.
 - 2) Overview of and recommendations for backing up and restoring the system configuration database
 - 3) Server maintenance
 - 4) Security Management: Assigning passwords and rights for various users on the server, workstations and GUI software
- d. Final Systems Operation Training
 - 1) The BAS Contractor shall conduct Final Systems Operation Training in accordance with Section 01 9113.
 - 2) Final Systems Operation Training provides the Owner and Operators a training session on whole-building operation. It shall focus primarily on BAS control of building systems and operation and its impact on building performance. System interactions shall be presented and discussed (such as a combined air handler, chiller, boiler, and terminal unit system), along with a detailed presentation of the sequences of operation and their relationship to the BAS. This training shall be conducted by the BAC with assistance from the CxA, and shall be attended by the Owner, Operators, Contractor, Design Team, and by any other Cx Team members deemed necessary by the CxA or the Owner.
 - 3) The Record BAS Shop Drawings shall be provided as a handout for the training.
 - 4) Scheduling, attendees, and training methods shall be as specified in Section 01 9113.

END OF SECTION

SECTION 23 0900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes control equipment, including but not limited to HVAC systems and components, control components for equipment not supplied with factory-wired controls
- B. Direct-Digital Control (DDC) system description
 - 1. The Controls Contractor shall supply and install a complete Direct Digital Control (DDC) Building Automation System (BAS) as required to accomplish the Sequences of Control for heating, ventilating, air-conditioning and other building-level equipment and systems as described herein.
- C. Furnish all labor, materials, equipment and service necessary for a complete and operational DDC BAS pursuant with this specification and as shown on the associated contract drawings.
- D. Provide all labor, material, equipment and service not specifically referred to in this specification or on associated drawings that are required to fulfill the functional intent of this specification at no additional cost to the Owner.

1.2 DEFINITIONS

- A. B-AAC: Advanced Application Controllers
- B. B-ASC: Application Specific Controllers
- C. ATC: Automatic Temperature Control
- D. BAS: Building Automation System
- E. B-AWS: Advanced Workstation Software
- F. B-OWS: Operator Workstation Software
- G. B-BC: Building Controllers
- H. BTL: BACnet Testing Laboratories
- I. DDC: Direct digital control.
- J. HLC: Heavy load conditions.
- K. I/O: Input/output.
- L. MS/TP: Multidrop Serial Bus/Token Passing.
- M. PC: Personal computer.
- N. PID: Proportional plus integral plus derivative.

- O. RSTP: Rapid spanning tree protocol.
- P. RTD: Resistance temperature detector.

1.3 CODES

- A. Comply with all applicable current codes, ordinances, and regulations.

1.4 REFERENCE STANDARDS

- A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.
- B. All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:
 - 1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - a. ANSI/ASHRAE Standard 135, BACnet
 - b. ASHRAE Guideline 36, High-Performance Sequences of Operation for HVAC Systems
 - 2. American National Standards Institute (ANSI)
 - 3. UL 916: Energy Management Systems
 - 4. BACnet Testing Lab
 - 5. UL 864 UUKL

1.5 DDC SYSTEM REQUIREMENTS

- A. DDC Systems installed under this specification shall strictly adhere to the following characteristics:
 - 1. Building Automation System (BAS) Direct Digital Controls (DDC) shall consist of native BACnet, microprocessor-based, peer-to-peer, networked, distributed devices utilizing the BACnet communication protocol in an open, interoperable system. The BAS also includes operator interface devices, programming and configuration software applications, DDC input/output devices, non-DDC automatic temperature controls, enclosures and interconnecting conduit and wire.
 - a. The BACnet operating stack must be embedded directly in every Device at the board level, and in all operator interface software packages.
 - b. No Gateways, Communication Bridges, Protocol Translators or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the BAS installation pursuant with this specification section. Gateways may only be used as required for communication to existing systems or systems installed pursuant with other specification sections. This requirement applies to non-Siemens or non-FMCS-compatible controllers, and that all controllers must comply with Siemens Desigo platform capabilities as approved by the SI Systems Engineering Division – Controls Branch.
 - c. DDC controllers that are not BACnet compliant shall not be acceptable under this specification and are strictly prohibited.

- d. The BAS provided under this section shall be manufactured by Siemens Industry, Beltsville, MD branch office, utilizing the Siemens Desigo platform. The system shall be an extension of, and fully integrated with, the existing SI-wide Siemens Facility Management and Control System (FMCS).
- e. The Owner shall receive ownership of all job specific configuration documentation, data files, programming tools, and application-level software developed for the project. This shall include all custom, job specific software code, databases and documentation for all configuration and programming that is generated for a given project and/or configured for use with the B-BC, BAS Server, and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for admin and programming level access to any component or software program shall be provided to the Owner.
- 2. The BAS shall be modular in nature and comprised of a network of stand-alone DDC devices. The System shall be designed and implemented in such a way that it may be expanded in both capacity and functionality through the addition of DDC Devices, sensors, actuators, etc.
- 3. All BAS controllers shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL).
- 4. Program database, data acquisition, and all control sequence logic shall reside in each DDC Device. The BAS shall not be dependent upon connection to a Server or Supervisor Controller for performance of the Sequence of Control as outlined in this specification. Each individual Device shall, to the greatest possible extent, perform its programmed sequence without reliance on the BAS network.
- 5. All BAS DDC Devices at all levels shall be fully custom-programmable in the field using the standard Operators Workstation Software. No configurable, canned program application specific controllers will be permitted.
- 6. All BAS DDC Devices shall be capable of updating firmware using software via internet without replacing any hardware, microprocessors or chips.
- 7. The BAS shall support remote annunciation of alarms and system events via printer, e-mail, and mobile device notifications (e.g., SMS, push alerts, or app-based messaging).
- 8. Actuation of control devices shall be electronic. Spring return fail-safe actuation shall be provided when loss of property and/or property damage is possible and where specified.
- 9. DDC Automatic Temperature Control (ATC) System shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started; along with the time delay between starts shall be user-selectable.
- 10. All binary output points shall be protected from short cycling via output configuration and/or programming. This feature shall allow minimum on time and off-time to be configurable.
- 11. The DDC System Manufacturer product line selected shall be the most current and complete offering from the manufacturer and shall currently be actively manufactured and supported at the time that this project is bid.
- 12. This project shall not be used as a test site. First release and test version hardware, software and firmware shall not be implemented on this project under any circumstances.
- 13. DDC System devices and spare components or equivalent shall be readily available for a minimum of five (5) years after the completion and final acceptance of this project.

1.6 BASIC SYSTEM ARCHITECTURE

- A. The DDC BAS as provided and installed under this specification shall be a complete system from a single manufacturer designed for use on intranets and the internet.

- B. The BAS shall consist of a 4-Tier network architecture.
1. Tier 1: Enterprise IP Network
 - a. The Enterprise tier includes all components connected to the Owner's enterprise LAN that provide system-level management, visualization, and analytics.
 - b. Tier 1 hosts the BAS Server, Advanced Operators Workstations (B-AWS), Client computers, analytic software packages, and peripheral devices such as printers and kiosks.
 2. Tier 2: Building Infrastructure
 - a. Tier 2 provides the high-speed BACnet/IP backbone for BAS communication and connectivity to host Building Controllers (B-BC), Network Infrastructure devices, communications, and wiring.
 - b. The building infrastructure provides the connectivity to which networked control devices connect. The Tier 2 devices shall be connected to the network via Ethernet over TCP/IP.
 3. Tier 3: Equipment Level Controllers
 - a. Tier 3 consists of a serial communication network to host field level DDC controllers such as Advanced Application Controllers (B-AAC), and Application Specific Controllers (B-ASC).
 - b. The equipment level controllers are connected to the Tier 2 BAS devices via RS-485 serial communication.
 4. Tier 4: End Devices (Field Sensors and Actuators)
 - a. Tier 4 consists of physical sensors and actuators that provide input and output for the BAS.
 - b. Tier 4 devices shall connect to Tier 3 controllers via hardwired I/O.
- C. The primary BAS components shall include but not be limited to:
1. BACnet Advanced Operator Workstation Software (B-AWS)
 2. Remote BACnet Advanced Operator Workstation Software (Remote B-AWS)
 3. Portable Operator Workstation Software (Portable B-OWS)
 4. Building Controllers (B-BC)
 5. Advanced Application Controllers (B-AAC)
 6. Application Specific Controllers (B-ASC)
- D. B-BCs shall automatically route BACnet communications to all configured available BACnet networks.
- E. B-AWS shall be fully IT-compatible devices that communicate directly on a TCP/IP Local Area Network (LAN).
1. LAN shall be 10/100/1000 Mbps TCP/IP with the following minimum requirements:
 - a. Cable: 1000 base-T, UTP-8 wire, category 6 or greater
 - b. Minimum throughput: 10 Mbps with the ability to increase to 1000 Mbps
 2. The Tier 1 Network shall provide communication between B-BCs, B-OWS, remote B-OWS and Web Server using a B/IP LAN backbone.
 3. B-BCs shall connect directly to the LAN and communicate using BACnet/IP without a TCP/IP Gateway or network server.
 4. B-AACs and B-ASCs shall communicate with B-BCs via BACnet MS/TP as the typical field-level protocol. B-AACs and B-ASCs shall not require direct BACnet/IP connections to the Owner's LAN.
 5. Coordinate implementation of the BAS on the Owner's LAN without disruption.

- F. BAS Manufacturer must natively support the following BACnet data links as defined in the ANSI/ASHRAE Standard 135, BACnet:
1. Point-to-Point (PTP)
 2. Multidrop Serial Bus/Token Passing (MS/TP)
 3. Ethernet (ISO 8802-3)
 4. BACnet IP (B/IP)
- G. Special Network Architecture Requirements:
1. Air-Handling Systems: For control applications of an air-handling system that consists of air-handling unit(s) and VAV terminal units, include a dedicated LAN of application-specific controllers serving VAV terminal units connected directly to the controller that is controlling air-handling-system air-handling unit(s). Basically, create a DDC system LAN that aligns with the air-handling system being controlled.
 2. Tier 3 Serial Networks: All controllers on a common serial network shall be configured to a common communication baud rate.
- H. Field sensors and control devices shall connect to peer-to-peer, fully programmable B-BC, B-AAC & B-ASC as required to achieve the point monitoring and Sequence of Control as specified herein. All devices are to be monitored by a B-AWS. Final control devices are to be electronic.
- I. Each Mechanical System and/or major piece of Mechanical Equipment shall have one (1) dedicated B-BC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.
- J. All BAS controllers, sensors and devices shall be UL listed.
1. All BAS controllers and interface devices must be UL 916 Listed.
- K. The new DDC BAS shall be connected to the Smithsonian's FMCS database server located within the Herndon Data Center (HDC) for full database management via Siemens software. All new controls shall be fully accessible through existing site-wide operator terminals and the FMCS database server. DDC panels and the FMCS database server shall be connected through the SI.edu network using TCP/IP over an Ethernet-routed network. The Controls Contractor is responsible for determining compatibility prior to submitting a bid and for all costs associated with connecting to the existing FMCS, including licensed software, programming, and training.
- 1.7 FMCS INTEGRATION REQUIREMENT
- A. Smithsonian operates on an existing FMCS (Siemens BAS). The intent of this specification is to extend and interoperate with this system. All components, software, and operations must be interoperable with the existing FMCS.
- B. The installed system shall interface directly with the existing FMCS database server. The existing software and database shall be modified with consultation from owner to accept new equipment. PC desktop icons that link to a separate system are not acceptable.

- C. Any costs associated with connecting to the existing FMCS, including licensed software, programming, and training, shall be part of the Controls Contractor's bid. The Contractor shall demonstrate the ability to perform the integration to the existing FMCS prior to bid submittal acceptance.
- D. The Controls Contractor shall coordinate all work associated with the FMCS connection. New DDC controls shall be connected/integrated to the FMCS over the SI.edu WAN via Ethernet connections.

1.8 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. DDC System Speed:
 - a. Response Time of Connected I/O:
 - 1) Update AI point values connected to DDC system every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - 2) Update BI point values connected to DDC system every five seconds for use by DDC controllers. Points used globally to also comply with this requirement.
 - 3) AO points connected to DDC system to begin to respond to controller output commands within two seconds. Global commands to also comply with this requirement.
 - 4) BO point values connected to DDC system to respond to controller output commands within two seconds. Global commands to also comply with this requirement.
 - b. Display of Connected I/O:
 - 1) Update and display analog point COV connected to DDC system every ten seconds for use by operator.
 - 2) Update and display binary point COV connected to DDC system every ten seconds for use by operator.
 - 3) Update graphic display refresh within 8 seconds.
 - 4) Point change of values and alarms displayed from workstation to workstation when multiple operators are viewing from multiple workstations shall not exceed graphic refresh rate indicated.
 - 2. Network Bandwidth: Design each network of DDC system to include spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage, and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions. Minimum spare bandwidth as follows:
 - a. Tier 1 Networks: 30 percent.
 - b. Tier 2 Networks: 30 percent.
 - c. Tier 3 Networks: 30 percent
 - 3. DDC System Data Storage:
 - a. Include capability to archive not less than 48 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends, and other information indicated.
 - b. Local Storage:
 - 1) Provide server with data storage indicated. Server(s) to use IT industry standard database platforms and be capable of functions described in "DDC Data Access" Paragraph.

4. DDC Data Access:
 - a. When logged into the system, operator able to also interact with any DDC controllers connected to DDC system as required for functional operation of DDC system.
 - b. Use for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
5. Future Expandability:
 - a. DDC system size is expandable to an ultimate capacity of at least 1.25 times total I/O points indicated.
 - b. Design and install system networks to achieve ultimate capacity with only addition of DDC controllers, I/O, and associated wiring and cable. Design and install initial network infrastructure to support ultimate capacity without having to remove and replace portions of network installation.
 - c. Operator interfaces installed initially do not require hardware and software additions and revisions for system when operating at ultimate capacity.
6. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
7. B-BC, B-AAC, & B-ASC shall be able to execute control loops at a selectable frequency at least 1 time every second. The controller shall scan and update the process value and output generated by this calculation at this same frequency at a minimum.
8. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
9. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
10. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
11. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 0.5 deg F (0.3 deg C).
 - b. Water Flow: Plus or minus 1 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 0.5 deg F (0.3 deg C).
 - e. Ducted Air Temperature: Plus or minus 0.5 deg F (0.3 deg C).
 - f. Outside Air Temperature: Plus or minus 0.5 deg F (0.3 deg C).
 - g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
 - h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
 - i. Relative Humidity: Plus or minus 5 percent.
 - j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
 - k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - l. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - m. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
 - n. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
 - o. Carbon Monoxide: Plus or minus 5 percent of reading.
 - p. Oxygen: Plus or minus 2 percent of reading.
 - q. Carbon Dioxide: Plus or minus 50 ppm.
 - r. Nitrogen Dioxide: Plus or minus 50 ppm.
 - s. Electrical: Plus or minus 5 percent of reading.

12. Overall combined system repeatability of sensors, controllers and readout devices for a particular application shall be plus or minus 2% of full scale of the operating range. Repeatability of overall combined system of sensor, controller and readout device in a control loop application will be plus or minus 5% of full scale of the operating range.
13. Long-term electronic drift shall not exceed 0.4% per year.
14. All components provided as part of this system shall operate under ambient environmental conditions of 20F to 104F dry bulb and 10% to 90% relative humidity, noncondensing as a minimum. Sensors and control elements shall operate under the ambient environmental temperature, pressure, humidity, and vibration conditions encountered for the installed location. B-OWS equipment (hardware only), such as CRTs and printers, shall, unless designated otherwise, operate properly under ambient environmental conditions of 45F to 90F and a relative humidity of 10% to 90%.
15. Networked components of the system shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%.

B. Energy Dashboard

1. Provide interactive, educational dashboard using a web application to display real-time energy data and building performance metrics in a common area shown on the drawings. Incorporate Owner branding and coordinate content with the Owner and A/E of record. Provide user interface for content management that allows the Owner to update text and photos. Provide one 48 inches wall-mounted commercial-grade monitor and infrared multi-touch overlay with 3-year warranty. Provide 24/7 content scheduler.

1.9 SEQUENCE OF OPERATIONS

- A. See the contract drawings for system sequence of operations for each system to be controlled.
- B. Program each DDC controller, third party equipment, etc., to perform the sequences of operation provided on the construction documents. Provide all necessary hardware on each piece of equipment in order for the equipment to perform the specified sequence and to meet the requirements of the point lists where provided.
- C. The Contractor shall be responsible for all control wiring connections, auxiliary devices and control wiring diagrams to complete the control system and attain the described sequence of operation.

1.10 ACTION SUBMITTALS

- A. Submit in writing and so delineated at the beginning of each submittal, known substitutions and deviations from requirements of Contract Documents. Deviation from Contract Documents must be approved by the Engineer of record prior to submittal.
- B. Sequence of Operations, Controls Diagram, BAS architecture, Bill of Materials, Controls Matrix and Points lists shall be a SEPARATE submittal (under separate cover) from all equipment product data associated with the controls system. Documents should be word searchable and utilize bookmarks.
- C. Complete BAS Engineering Design Submittal & Drawings shall be prepared pursuant with the following guidelines:

1. Submittal documentation and drawings shall consistently use the same abbreviations, symbols, nomenclature and identifiers. Each control system element shall be assigned a unique identifier pursuant with the Contract Documents.
 2. Submittal documentation and drawings shall have at the beginning an Index and Design Drawing Legend.
 - a. Index shall list all design drawings and elements including the drawing number, sheet number, drawing title, etc.
 - b. Legend shall show and describe all symbols, abbreviations and acronyms used on the Design Drawings.
- D. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- E. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 3. Wiring Diagrams: Power, signal, and control wiring.
 4. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Each desktop workstation network port, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Information, drawn to scale.
 - g. Proposed routing of wiring, cabling, conduit, and tubing; coordinated with building services for review before installation.
 5. Riser diagram of the building communication network shall outline execution and details of all network cabling, BAS & Network Hardware including the following:
 - a. All BAS/DDC Hardware with controller number, unique identifier/tag, location, equipment and service.
 - b. All Network Hardware with unique identifier, location and service.
 - c. Network cabling configuration and execution specification.
 - d. Location of all cabling termination points and End of Line (EOL) terminators.

- e. Location of all network interface jacks.
- f. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or optical fiber cable type. Indicate raceway type and size for each.
- g. A separate riser diagram shall be provided for each network segment.
6. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates, and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
7. A schedule of all BAS network devices including the unique equipment identifier/tag, description, IP address, MAC address, control panel name, and installation location.
8. A schedule of all control valves including the unique equipment identifier/tag, valve size, dimensions and installation/maintenance clearance, model number (including pattern and connections), close-off rating, flow, CV, pressure drop, pressure rating and location. The valve schedule shall also contain actuator selection data supported by calculations of the force required to move, close and seal the valve at design conditions.
9. A schedule of all control dampers. This shall include the unique equipment identifier, unique damper identifier/tag, damper size, pressure drop, blade configuration, orientation and axis of frame, blade rotation, location and selection criteria of actuators, nominal and actual sizes, and manufacturer and model number. The Damper Schedule shall include the AMCA 500-D maximum leakage rate at the operating static-pressure differential.
10. Sequence of Operation shall be submitted for every piece of equipment being controlled by and/or associated with the BAS. No operational deviation from specified Sequences of Operation as outlined in Contract Documents shall be permitted without prior written approval. Sequences of Operation shall include and conform to the following:
 - a. Refer to equipment and control devices by their specific unique identifiers/tags pursuant with the Contract Documents and BAS Submittal package.
 - b. Clearly represent actual Application Programming methodology and functional control operation. Do not merely provide a copy of Contract Document specified Sequence of Control.
 - c. Include description of functional system operation under normal and failure conditions.
11. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
12. Control System Software:
 - a. Cross-referenced listing of software to be loaded on each operator workstation, server, and DDC controller.
 - b. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
 - c. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
 - d. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.

- e. Listing and description of each engineering equation used with reference source.
 - f. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
 - g. Description of operator interface to alphanumeric and graphic programming.
 - h. Description of each network communication protocol.
 - i. Description of system database, including all data included in database, database capacity, and limitations to expand database.
 - j. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden, and system throughout.
 - k. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
13. Color graphics indicating the following:
- a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics, and data displayed.
 - c. Intended operator access between related hierarchical display screens.
14. Controlled Systems:
- a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, point type, type of device, manufacturer, model number, trend configuration, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that to be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
- 1.11 INFORMATIONAL SUBMITTALS
- A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
 - B. Qualification Data: For Installer and manufacturer.
 - C. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
 - D. Field quality-control test reports.

1.12 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
1. Operator's Manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 2. Programming Manual including:
 - a. Documentation of all project specific Application and DDC programs.
 - b. All necessary system Administrator-Level passwords and/or required access credentials.
 - c. Information required for programming BAS.
 - d. Complete Final Point Schedule including all hardware and software data points and documentation of calibration and configuration values for all Inputs, Outputs, Variables and PID Loops at the conclusion of systems commissioning and functional testing.
 - e. Routine preventative maintenance procedures, corrective diagnostic troubleshooting procedures and calibration processes.
 - f. Final Bill of Material with all installed parts, manufacturers, manufacturers' part numbers and ordering information.
 - g. A schedule of recommended spare parts with part numbers and supplier.
 3. Complete system database as functional at the conclusion of systems commissioning and functional testing including all graphics and images used by and/or created for BAS on electronic format as accepted by Owner.
 4. Maintenance instructions and lists of recommended spare parts for each type of control device.
 5. Interconnection wiring diagrams with identified and numbered system components and devices.
 6. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 7. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 8. Calibration records and list of set points. Including calibrated trip points for differential pressure switches.
 9. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 10. Names, addresses, email addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 11. Owner training materials.
- B. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens for all major equipment or systems, such as; chilled water plant including all components, typical air handling units, etc.
 5. Software license required by and installed for DDC workstations and control systems.

- C. Project Record Documents. Upon completion of installation and systems commissioning submit record documents for review. As-Built• Project Record Documents should include:
1. Project Record Application Engineering Drawings shall include all BAS System Engineering Design Submittal with Drawings updated to reflect actual field conditions, architecture and execution.

1.13 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish a recommended list of materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Two Relays each type.
 2. Two Space sensors each type.
 3. One Duct sensor each type.
 4. One actuator each type.
 5. One duct pressure DPT.
 6. One transformer each type.
 7. One controller each type.
 8. One Supervisory controller each type.

1.14 QUALITY ASSURANCE

- A. DDC System Manufacturer Qualifications:
1. Nationally recognized manufacturer of DDC systems and products.
 2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 3. DDC systems and products that have been successfully tested and in use on at least five past projects.
 4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
 - e. Owner operator training.
- B. DDC System Provider Qualifications:
1. Authorized representative of, and trained by, DDC system manufacturer.
 2. Authorized Siemens Industry representative operating from the Siemens factory/corporate branch office in Beltsville, MD, in accordance with Smithsonian Design Standards §23.2.16.2. In-place facility located within 50 miles of Project.
 3. Demonstrate past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
 4. Demonstrate past experience on five projects of similar complexity, scope, and value.
 5. Demonstrate past experience of each person assigned to Project.
 6. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 7. Service and maintenance staff assigned to support Project during warranty period.

8. Product parts inventory to support ongoing DDC system operation for a period of not less than five years after Substantial Completion.
 9. DDC system manufacturer's backing to take over execution of the Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASHRAE 135 for DDC system components.
- 1.15 EXTENDED WARRANTIES
- A. Warrant all DDC controllers to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of two (2) years at a minimum.
- B. Warrant all carbon dioxide (CO₂) sensing elements to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of three (3) years at a minimum.
- C. Warrant all relative humidity (RH) sensing elements to be free of defect in material and workmanship under normal operation and expected service as published by the manufacturer in the unit's performance specifications for a period of three (3) years at a minimum.
- D. Warrant all other components of the BAS and installation to be free of defects in workmanship and material under normal expected service and use for a period of two (2) years from the date of final acceptance of the BAS by the Owner.
- E. During the warranty period, provide all labor and materials required to repair or to replace all items or components that fail due to defects in workmanship or manufacture at no charge or reduction in service to the Owner.
- F. Except in the event of property loss or damage, warranty service shall be provided during regular working hours Monday through Friday at no charge unless otherwise explicitly outlined in the Contract Documents. Warranty work outside these periods and associated charges shall be coordinated with Owner.
- 1.16 DELIVERY, STORAGE, AND HANDLING
- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.
- 1.17 COORDINATION
- A. Coordinate location of all thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

- B. Coordinate with all related systems, subcontractors and the associated manufacturers responsible for the system to determine the points that are to be mapped from the third party system to the BAS. At a minimum, provide mapping, alarm configuration, and graphic creation for each system.
- C. Coordinate systems outside of Divisions 23 that have been included as a part of the overall BAS system. Achieve compatibility with systems and equipment that interfaces with the BAS systems. Such systems may include;
 - 1. Plumbing Metering.
 - 2. Plumbing Equipment provided under Division 22.
 - 3. Intrusion Detection.
 - 4. Access Control and Security Systems.
 - 5. Clock Systems.
 - 6. PLC Electronic Detention Monitoring and Control Systems.
 - 7. Addressable-fixture Lighting Controls.
 - 8. Digital, Addressable Fire Alarm System.
 - 9. Electrical Power Monitoring and Control.
 - 10. Panelboards.
 - 11. Motor-Control Centers.
 - 12. Emergency Power Equipment.
 - 13. Conditioned electrical branch circuits for BAS devices.
 - 14. Natural Gas Metering System.
 - 15.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Siemens Building Technologies.
- B. The DDC BAS shall be provided by Siemens Industry, factory/corporate branch office in Beltsville, MD. The system shall utilize the Siemens Desigo platform and shall be an extension of the existing SI-wide Siemens Facility Management and Control System (FMCS) per Smithsonian Design Standards §23.2.16.2.
- C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
- D. Incorporate other monitored or controlled systems identified in paragraph 1.17.C above.

2.2 BACNET ADVANCED OPERATORS WORKSTATION PLATFORM (B-AWS)

- A. The BACnet Advanced Operator Workstation Platform (B-AWS) provides complete configuration, monitoring, modification and operation of the entire DDC System by advanced building operators and technicians.
- B. Provide as specified herein complete all associated Operating System, Operators Workstation Application Software and Third-Party Software Applications preloaded and configured.
- C. BACnet Advanced Operator Workstation Platform (B-AWS) shall reside on the Tier 1 Network using the BACnet/IP data link as specified in ANSI/ASHRAE Standard 135.
- D. Communications and Protocols
 - 1. B-AWS information access for the control system shall utilize the BACnet protocol only for communication to B-BCs, B-AACs, B-ASCs and all other BAS DDC controllers.
 - 2. B-AWS shall reside on the same LAN as B-BCs. B-AWS shall as a minimum support point-to-point (PTP) and BACnet/IP physical/data link layer protocols.
 - 3. The B-AWS specified here may, at the Owner's option, be located remote from the BACnet internetwork. Other than the difference in B-AWS communication speed, the system shall be capable of remote operation via BACnet LAN types with no degradation in application performance.
 - 4. B-AWS Operating System (OS) Software shall be consistent on all B-AWS hardware platforms provided.
 - 5. B-AWS Application Software shall be provided and licensed to Owner. Provide latest versions of software available.

2.3 CONTROL SYSTEM ADVANCED OPERATORS WORKSTATION (B-AWS) APPLICATION SOFTWARE

- A. BACnet Advanced Operator Workstation Platform (B-AWS) software shall comply with the minimum requirements of ANSI/ASHRAE Standard 135 Annex L for a B-AWS and shall be certified and listed by the BACnet Testing Laboratories (BTL) as a B-OWS. BTL product listings are available from BACnet international.
- B. System Configuration
 - 1. The workstation shall provide a complete engineering tool for the configuration of the system. This shall allow for future system changes under proper password protection including dynamic creation, deletion and modification of all configuration parameters, programs, graphics, trend logs, alarms, schedules and every BACnet object used in the installed system.
- C. Security
 - 1. Each operator shall be required to log on to the system with a unique user name and password in order to view, edit, add or delete data.
- D. Operators will be able to perform only those commands available for their respective passwords.
 - 1. System security permissions shall be multi layered and defined for each individual operator to restrict/permit day-to-day operations and system configuration.

- a. A minimum of 10 levels of access shall be supported with a configurable matrix of operator actions allowed for each access level, broken down into at least 200 possible operator actions.
 - b. A minimum of 50 passwords shall be supported at each B-OWS.
 2. An administrator-level operator shall have the ability to configure credentials for all other operators.
 3. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving B-AWS in an unsupervised logged-in state.
 4. Security data shall be stored in an encrypted format.
- E. Alarming and Event Notification
 1. B-AWS shall utilize BACnet Alarm Events and Protocol Implementation Conformance Statement (PICS) shall support at a minimum the following BACnet Interoperability Building Blocks (BIBBs):
 - a. Alarm and Event - Acknowledge-A (AE-ACK-A)
 - b. Alarm and Event - Notification-A (AE-N-A)
 - c. Alarm and Event - Alarm Summary View-A (AE-AS-A)
 - d. Alarm and Event - View and Modify-A (AE-VM-A)
 - e. Alarm and Event - View Notifications-A (AE-VN-A)
 2. The workstation shall display and log alarms and events from any BACnet object in the system and shall support operator configuration of the alarm limits, differentials, states and reactions for each object in the system.
 3. The alarms shall be filterable based on level, date, and time. Nuisance alarms shall be suppressed using hierarchical alarm suppression and delay logic.
 4. There shall be 4 levels of alarms:
 - a. Level 1: Critical/Life Safety
 - b. Level 2: Critical Equipment Message
 - c. Level 3: Urgent Message
 - d. Level 4: Normal Message
 5. B-AWS terminal shall provide audible, visual, and printed means of alarm and event notification.
 6. System shall provide log of notification messages. Complete Alarm log of all system and operator transactions shall be archived to the hard disk of the system B-AWS.
 7. Alarm messages shall be in user-definable text (English) and shall be entered either at the B-AWS terminal or via remote communication.
 8. An alarm summary shall be available to show all alarms whether including but not limited to whether or not they have been acknowledged.
 9. System shall provide ability to prioritize and differentiate communications for at least 20 different levels of alarms.
 10. Alarm messages shall be fully customizable in size, content, behavior and sound.
 11. The operator shall be able to view all system alarms from any location in the internetwork. With the proper credentials, an operator shall be able to acknowledge and clear alarms. Alarm and Event Log shall be configurable per workstation and shall display at a minimum alarm time, received time, state, notification class, priority, message, source, time acknowledged, acknowledged by user and action.
 12. All critical alarms shall be hard-wired between the DDC control panel and equipment. Use of network communications alone for annunciation of critical alarms is not acceptable per Smithsonian Design Standards §23.2.16.6.b. Network alarm annunciation may be provided in addition to, but not as a substitute for, hard-wired critical alarm connections.

- F. Weekly Annual and Special Event Scheduling
1. B-AWS Software shall utilize BACnet Schedules and PICS shall support at a minimum the following BIBBs:
 - a. Scheduling - Advanced View and Modify-A (SCH-AVM-A)
 2. Provide ability to view and modify the schedule for the calendar week and up to 255 special events in a graphical format. Each calendar day and special event shall provide at least ten time/value entries per day.
 3. Provide the ability for the operator to select scheduling for either binary, analog, or multi-state object values.
 4. Provide the ability for the operator to designate days, date ranges, or repeating date patterns as exception schedules.
 5. Provide the capability for the operator to define special or holiday schedules and to link the BACnet schedule to a BACnet calendar, thereby over-riding weekly schedule programming on holidays defined in the BACnet calendar.
 6. There shall be a provision with proper password access to manually override each schedule.
 7. Provide the capability to designate any exception schedule to be "Executed Once• " then automatically cleared.
 8. Provide the ability to name each exception schedule with a user defined term to describe each special event.
 9. The schedule objects shall reside in each individual device. Workstation or server-based scheduling shall not be acceptable.
- G. Trend Log Graphing
1. The B-AWS shall support both the BACnet Trend Log and the BACnet Trend Log Multiple standard objects for defining custom trend logs for any object in the system. This definition shall include interval, length, start time and end time.
 - a. The trend data shall be sampled and stored in each individual BACnet device where the object is stored. The workstation or another field level integration platform shall not be required for storage of custom trend logs.
 - b. All long-term data archival to hard-disk shall be performed by a BTL-Listed BACnet device dedicated for this service.
 2. PICS shall support at a minimum the following BIBBs:
 - a. Trending - View-A (T-V-A)
 3. All data points (both hardware and software) system-wide shall be assignable to a historical trending program by gathering configurable historical samples of object data stored in the local controller (B-BC, B-AAC, B-ASC).
 4. All trend log information shall be displayable in text and graphic format. All information shall be able to be printed in black & white and color and exported directly to a Microsoft Excel Spreadsheet.
 5. The B-AWS shall perform the following at a minimum:
 - a. Be capable of automatically retrieving any trend-log from any device on the network without user-intervention.
 - b. Manage connection to internetwork automatically based upon configurable data acquisition thresholds; retrieving data only when necessary rather than streaming data.
 - c. Shall operate as a Microsoft Windows service.
 - d. Be capable of exporting data directly to Microsoft Excel.

- e. Not require a separate viewer • but shall seamlessly present all archived data together with real-time data stored in device using the standard B-AWS Trend Log Viewer.
- H. Runtime Log Information
- 1. B-OWS Software shall be capable of displaying Runtime and On/Off Cycle data of all Binary data points (both hardware and software) system-wide.
 - 2. Runtime data shall be sampled and stored in each individual BACnet device where the object is stored using standard BACnet objects and published properties. The workstation shall not be required for storage of custom runtime logs.
 - 3. At a minimum, the Runtime data shall include:
 - a. Total accumulated active time.
 - b. Total accumulated active transitions and active transitions for the current day.
 - c. Timestamp and duration for each change of state for the last 100 transitions.
- I. System Configuration, Set-Up and Definition
- 1. Device and network status shall be displayed for any device on the BACnet internetwork. At a minimum the following Device Management BIBBs shall be supported:
 - a. Device Management - Automatic Device Mapping-A (DM-ADM-A).
 - b. Device Management - Automatic Network Mapping-A (DM-ANM-A).
 - 2. All control strategies and energy management routines shall be stored in the controller and shall allow modification and additions by the operator using the B-AWS software. No strategies or routines shall be stored on the B-AWS platform.
 - 3. B-AWS Software shall have the capability to back-up and restore the programming and database of any BACnet device on the BACnet internetwork. The B-AWS BTL listing shall support the Device Management - Backup and Restore-A (DM-BR-A) BIBB.
 - 4. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system.
- J. Graphical User Interface (GUI)
- 1. B-AWS Software shall support, at a minimum, the following graphic file formats: PNG, JPG, TIF, DIB, SVG, EMF, and HTML5. The GUI shall allow for the use of custom animations and interactive elements developed using modern web technologies such as JavaScript and URL hyperlinks. Deprecated formats such as Flash (SWF) shall not be used.
 - 2. B-AWS Software shall provide a color graphics package to allow the user to generate custom dynamic graphics for graphical representation of system design and system parameters. Graphic images may reside on the B-AWS or server; however, all dynamic data and attributes must reside in the controller.
 - a. A listed set of symbols and graphic slides shall be available to allow operators to select from the graphics table to assist in graphic generation.
 - b. All color graphic displays shall be dynamic with current point data automatically updated from the BACnet internetwork to the B-AWS workstation without operator intervention.
 - c. The operator shall be able to manually adjust all data point values (hardware or software) in the system, adjust values of control loops, and command points to local mode or release points to automatic mode.
 - d. The windowing environment of the B-AWS shall allow the user to simultaneously view several graphics at the same time to analyze total building operation, and/or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

- e. Pre-packaged animations for display of fans, pumps, dampers, etc., and shall allow custom user-created animations to be used to display objects on graphic displays.
- K. Programming Software:
- 1. Include programming software to execute sequences of operation indicated.
 - 2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
 - 3. Programming Software: Any of the following:
 - a. Graphic-based programming is the easiest method of programming options indicated and best suited for operators with limited programming experience. Not all DDC system manufacturers offer graphic-based programming. Consult manufacturers.
 - 1) Graphic Based: Use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 2) Assemble function blocks with interconnection lines that represent to control sequence in a flowchart.
 - b. Make programming tools viewable in real time to show present values and logical results of each function block.
 - c. Menu Based: Done by entering parameters, definitions, conditions, requirements, and constraints.
 - d. Line by Line and Text Based: Programming is to declare variable types such as local, global, real, integer, and so on, at the beginning of the program. Use descriptive comments frequently to describe programming code.
 - 4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.
- L. The BAS shall include fully automated diagnostic procedures for verification of internetwork communication integrity. Upon detection of a communications failure, the system shall automatically generate an alarm. The B-AWS software shall support remote annunciation of alarms and system events via printer, e-mail, and mobile device notifications (e.g., SMS, push alerts, or app-based messaging).
- M. Control Summaries, Reports and Logging:
- 1. The system shall provide self-documentation reporting to summarize control strategies for any point or any user selected group of points within the Control System.
 - 2. The B-AWS reporting package shall allow the user to configure the point information display in custom format.
 - 3. The B-AWS shall enable operator to perform Wild Card data point sorting and searches.
 - 4. The B-AWS shall perform automated network back-up of runtime databases in all devices on the BACnet network according to operator configurable schedule and storage directory structure.
 - 5. Standard Reports: Provide standard DDC system reports with operator ability to customize reports later.
 - a. All I/O: With current status and values.
 - b. Alarm: All current alarms, except those in alarm lockout.
 - c. Disabled I/O: All I/O points that are disabled.
 - d. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 - e. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 - f. Logs:

- 1) Alarm history.
 - 2) System messages.
 - 3) System events.
 - 4) Trends.
6. Custom Reports: Operator able to easily define and prepare any system data into a daily, weekly, monthly, annual, or other historical report. Reports to include a title with time and date stamp.

2.4 BUILDING LEVEL CONTROLLERS (B-BC)

- A. All building level controllers shall comply with the minimum requirements of ANSI/ASHRAE Standard 135 Annex L for a BACnet Building Controllers (B-BCs) and shall be certified and listed by the BACnet testing Laboratories (BTL) as a B-BC.
- B. Furnish B-BC(s) as necessary to control large point count major mechanical equipment, and execution of BAS global strategies, and as noted in the execution portion of this specification.
 1. Each Mechanical System and/or major piece of Mechanical Equipment (e.g., Chilled Water, Heating Water, Large AHU, etc.) shall have one (1) dedicated DDC controller with sufficient I/O capacity such that it shall be connected to ALL field devices and sensors associated with that system and/or piece of equipment. Distributed control of one (1) single piece of major mechanical equipment shall not be performed by multiple controllers.
 2. Each B-BC shall support local hardware Inputs and Outputs (I/O) by the use of on-board I/O and/or I/O expansion modules.
- C. Building level controllers shall reside on the Tier 2 network using BACnet/IP, BACnet/Ethernet, or MS/TP data links as specified in ANSI/ASHRAE Standard 135
- D. Building level controllers (B-BCs) shall reside on the field MS/TP network for communication with downstream B-AAC and B-ASC devices. B-BCs shall additionally provide a BACnet/IP interface port for upstream connection to the SI.edu network and the FMCS database server only. B-BCs shall support both BACnet MS/TP (field side, typical) and BACnet/IP (server side, for FMCS connectivity) simultaneously.
- E. B-BC shall be capable of locally executing global strategies for the BAS based on information from any object in the internetwork. Control Systems that require a higher-level host processor for update, time stamps, global point data, COS transfer, on-line control instruction, or communications control between B-BC panels shall not be acceptable.
- F. BAS shall communicate with all B-AWS, B-BC, B-AAC & B-ASC on a peer-to-peer basis, and shall provide real-time clock functions for scheduling and network-wide time synchronization.
- G. B-BC shall have sufficient memory to support its operating system, database, and programming requirements. Battery/capacitor shall retain static RAM memory and clock functions for a minimum of 72 hours.
 1. B-BC operating system, field database, and application programs shall reside in EEPROM.
 2. B-BC run-time field database and application programs shall reside in battery backed-up on-board memory of EEPROM.
- H. B-BC shall comply with the following Hardware Configuration:

1. B-BC shall have integral power switch. If the device manufacturer provides no on-board switch then the System Contractor shall provide a separate dedicated transformer and switch within each enclosure for each controller present.
 2. B-BC shall provide diagnostic LEDs for power, communications and processor status. The B-BC shall continually check the status of its processor and memory circuits.
 3. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement.
 4. All hardware inputs shall be Universal (i.e., binary or analog) configured on hardware and/or in software.
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, 0-5VDC, and 0-10VDC.
 - b. Pulse accumulation shall accommodate a maximum frequency of 40Hz.
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
 - d. 24VAC over-voltage protection
 - e. Status LED indicators for each input
 5. All hardware outputs shall be Universal and configured on hardware and/or in software.
 - a. Outputs shall provide configurable modulating signal to industry standard 0-5VDC, 0-10VDC, and 4-20 mA analog control devices and relays.
 - b. Outputs shall be capable of sourcing 75mA at 12VDC.
 - c. Outputs shall have a minimum 8 Bit D/A conversion resolution.
 - d. 24VAC over-voltage and short protection
- I. B-BC shall interact with the Control System Application Software in compliance with the following:
1. Database programming, configuration and modification shall be accomplished through the B-AWS online with the B-BC. The complete database and application program shall reside in the B-BC. The System Contractor shall configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents. Provide a copy of all programming on disc to the Owner.
 2. The B-BC shall function in a real-time, multi-tasking networked operating environment; able to display database values, programs, and control loops in real-time while functional and online using the B-AWS. The user shall be able to add, delete, or modify objects on-line as required without taking the B-BC offline. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary to execute the specified sequence of control.
 3. All required application programming shall be resident in the B-BC, B-AAC & B-ASC, and not in the B-AWS.
 4. B-BC shall manage system-wide alarms by performing distributed, independent alarm analysis and filtering. At no time shall the B-BC panel's ability to report alarms be affected by either operator activity at a B-AWS or local I/O device, or communications with other B-BC on the network.
 - a. B-BCs shall have capability to broadcast alarm conditions automatically across the Tier 1 or Tier 2 network. Alarm Event notifications shall be sent to off-site computer or serial printer. A minimum of one B-BC per site shall be capable of sending SMTP email messages to an email server for configured alarm conditions.
 - b. Active Alarm Events log shall be stored on the B-BC and may be viewed locally or remotely.
 - c. All alarm or point change reports shall include the point's English language description, and the time and date of occurrence.

- d. The user shall be able to define the specific system reaction for each point alarm and shall be able to customize reaction and filtering to minimize nuisance reporting. Each B-BC panel shall automatically inhibit the reporting of selected alarms during the standby power modes of operation, loss of power, fire alarm mode, and normal system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.
 - e. Alarm reports, messages, and files can be directed to a user-defined list of operator devices, or PCs used for archiving alarm information.
 - 5. B-BC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
 - a. B-BC panels shall store point history files for all analog and binary inputs and outputs.
 - b. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
 - c. Trend data shall be stored at the stand-alone B-BC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired. B-BC shall be equipped with enough storage for a minimum of 24 hours of trend data.
 - 6. Stand-alone B-BC panels shall automatically accumulate and store runtime hours for binary input and output points.
 - 7. B-BC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.
 - 8. B-BC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.
- J. Communication and Protocols
- 1. The B-BC shall continuously scan the BACnet network and maintain a current database of field data in on board battery/capacitor backed RAM or EEPROM, including alarms, passwords, binding tables, device status, etc. The B-BC shall communicate with BACnet devices on the Tier 3 network using the BACnet physical data link MS/TP at a baud rate of no less than 76.8 Kbps where not limited by third party BACnet devices such as variable frequency drives, utility meters, etc.
 - 2. The B-BC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the network using BACnet/IP.
 - 3. B-BC shall support and be capable of monitoring and controlling a network of communicating remote space sensors. These networked sensors shall occupy input/output hardware points in the B-BC.
 - 4. B-BC shall support at a minimum of two (2) distinct dedicated BACnet/IP (B/IP) data link networks using TCP/IP and one (1) BACnet/Ethernet data link network simultaneously.
 - 5. Building level controllers shall support the following communications requirements at a minimum:
 - a. Client and Server BACnet Subscribe Change of Value (COV) Service.
 - b. Client and Server BACnet Read Property Multiple (RPM) Service.
 - c. BACnet transmit and receive frame segmentation.
 - d. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.
 - 6. Building level controllers shall support SMTP and provide stand-alone remote annunciation of alarms via e-mail without additional hardware, B-AWS or web-server.

2.5 ADVANCED APPLICATION CONTROLLERS (B-AAC)

- A. B-AAC shall comply with all aforementioned BAS System Requirements and shall comply with or exceed the BACnet profile for Advanced Application Controllers (B-AAC).
- B. Furnish one dedicated B-AAC(s) for each small or medium sized mechanical system. Additionally, furnish one dedicated B-AAC for each Terminal Unit Mechanical Device on the project. Those include Variable Air Volume (VAV) Air Terminal Units (ATU), Serial and Parallel Fan-Powered (FP) VAV ATUs, Unit Heaters (UH), Unit Ventilators (UV), Fan Coil Units (FCU) and Individual Fans.
- C. Each B-AAC shall acquire, process, and store point input data on a real time basis for internal use and for sharing with other controllers. Each B-AAC shall also maintain and supervise digital and analog output signals to the control devices and have a real time operating system capable of time of day scheduling and other time based functions.
 - 1. If the hardware point requirements of any medium-sized system should exceed the I/O configuration of available B-AAC offerings then a B-BC must be used. Control of one piece of mechanical equipment may not be performed by more than one controller.
- D. B-AAC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory.
- E. Each B-AAC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet Tier 2 or Tier 3 network.
- F. Control systems that utilize canned programs or programmable read only memory (PROM) level application programming are not acceptable.
- G. Once downloaded, a B-AAC shall not require further communication with the B-AWS except for data base changes, operator commands, and requests from the B-AWS for B-AAC data. Programming of B-AACs shall be completely modifiable in the field, over the installed BACnet network.
- H. Each B-AAC shall be provided with the ability to prevent unauthorized access to its software program.
- I. B-AAC shall have sufficient memory to support its operating system, database, and programming requirements.
 - 1. B-AAC operating system, field database, and application programs shall reside in EEPROM.
- J. B-AAC run-time field database and application programs shall reside in on-board memory or EEPROM.
- K. B-AAC shall feature real-time 24-hour clock and 365-day calendar. Battery or capacitor back-up of these functions is required where the B-AAC is installed as a standalone controller.

- L. B-AAC shall feature a software configurable audible enunciator which shall be configured to trigger on the occurrence of selected alarms, and shall be audible and acknowledgeable either to all users, or only to those users with sufficient password authority.
- M. B-AAC shall comply with the following Hardware Configuration:
1. B-AAC shall provide diagnostic LEDs for power, communications and processor status. The B-AAC shall continually check the status of its processor and memory circuits.
 2. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, 0-5VDC, and 0-10VDC
 - b. Pulse accumulation shall accommodate a maximum frequency of 100Hz
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution
 - d. 24VAC over-voltage protection
 3. Hardware Outputs shall be configured as to be modular in nature.
 4. Universal hardware outputs shall be provided and configured on hardware or in software and comply with the following:
 - a. Universal Outputs shall provide configurable modulating signal to industry standard 0-5VDC, 0-10VDC, and 4-20 mA analog control devices and relays.
 - b. Outputs shall be capable of sourcing 75mA at 12VDC and 24VDC.
 - c. Outputs shall have a minimum 8 Bit D/A conversion resolution.
 - d. 24VAC over-voltage and short protection.
- N. B-AAC for VAV ATUs application shall comply with the following additional requirements:
1. B-AAC shall be provided with integral damper actuator. Actuator shall feature the following at a minimum:
 - a. 35 in-lbs of torque.
 - b. Brushless DC Operator.
 - c. Actual damper position feedback. Drive time or other software calculated damper position shall not be accepted.
 - d. Damper End Switch using motor current sense or equivalent for positive feedback of both end stop positions.
 - e. Software selectable rotation.
 2. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
 - a. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
 3. Airflow Calibration, Test and Air Balance, etc. shall be performed via dedicated handheld configuration tool connected directly to communication port located at ATU B-ASC sensor. Special proprietary software and/or applications loaded on a computer, tablet or other similar device shall not be acceptable to perform this function.
- O. B-AAC for unitary applications shall comply with the following additional requirements:
1. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement.
 2. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
 - a. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
- P. Control System Application Software:
1. The B-AAC application software shall be the same as and indistinguishable from the B-BC specified interaction with the Control System Application Software.

2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-AWS online with the B-AAC. The complete database and application program shall reside in the B-AAC. Configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
3. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.

Q. Communications and Protocols

1. When connected to the Tier 2 network, the B-AAC shall communicate with field devices and controllers using the BACnet physical IP data link. The B-AAC shall support daisy chain, star, or IP ring topology as required.
2. When connected to the Tier 3 network, the B-AAC shall communicate with field devices and controllers using the BACnet physical data link MS/TP at 76.8 Kbps where not limited by third party devices such as variable frequency drives, utility meters, etc.
3. The B-AAC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the network.
4. B-AAC shall support and be capable of monitoring and controlling a network of a minimum of four (4) communicating remote space sensors. These networked sensors shall not consume input/output hardware points in the B-AAC.

R. B-AAC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.

1. B-AAC panels shall store point history files for all analog and binary inputs and outputs.
2. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
3. Trend data shall be stored at the stand-alone B-AAC panels, and uploaded to hard disk storage automatically at preconfigured intervals when archival is desired. B-AAC shall be equipped with enough storage for a minimum of 24 hours of trend data.

S. Stand-alone B-AAC panels shall automatically accumulate and store runtime hours for binary input and output points.

T. B-AAC panels shall automatically sample, calculate and store consumption totals on a daily, weekly, or monthly basis for user-selected analog and binary pulse input-type points.

U. B-AAC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.

V. B-AAC shall support, transmit, and receive of segmented messages.

2.6 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

- A. B-ASC shall comply with all aforementioned BAS System Requirements and shall comply with the BACnet profile for Application Specific Controllers (B-ASC).
- B. B-ASC shall reside on the Tier 2 or Tier 3 network using the BACnet/IP or BACnet MS/TP data link as specified in ANSI/ASHRAE Standard 135 in compliance with the following requirements at a minimum:

1. Automatically detect the baud of the MS/TP network and then configure the device's communication baud to match that of the MS/TP network.
- C. B-ASC shall support the following communications requirements at a minimum:
 1. Client and Server BACnet Subscribe Change of Value (COV) Service.
 2. Client and Server BACnet Read Property Multiple (RPM) Service.
 3. BACnet transmit and receive frame segmentation.
 4. Post-installation, field-configurable maximum information frames, APDU frame timeout, APDU segment timeout and APDU retries.
- D. B-ASC controllers are only permitted when they can meet the full requirements of the project's sequence of operation. Provide one dedicated B-ASC for each Terminal Unit Mechanical Device on the project. Those include Variable Air Volume (VAV) Air Terminal Units (ATU), Serial and Parallel Fan-Powered (FP) VAV ATU's, Unit Heaters (UH), Unit Ventilators (UV), Fan Coil Units (FCU) and Individual Fans.
- E. B-ASC shall provide microprocessor based self-contained stand-alone fully programmable operation of local process control loops. All local level application programs shall be installed on individual controllers in non-volatile memory.
- F. Each B-ASC shall be capable of sharing point information with other B-BC, B-AAC, or B-ASC on a peer-to-peer basis via the BACnet Tier 2 or Tier 3 network.
- G. Control systems that utilize canned programs or programmable read only memory (PROM) level application programming are not acceptable.
- H. Once downloaded, a B-ASC shall not require further communication with the B-AWS except for data base changes, operator commands, and requests from the B-AWS for B-ASC data. Programming of B-ASCs shall be completely modifiable in the field, over installed BACnet Internetwork.
 1. Each B-ASC shall be provided with the ability to prevent unauthorized access to its software program.
 2. B-ASC shall have sufficient memory to support its operating system, database, and programming requirements.
 3. B-ASC operating system, field database, and application programs shall reside in EEPROM.
 4. B-ASC run-time field database and application programs shall reside in on-board non-volatile memory or EEPROM.
- I. B-ASC shall perform and manage historical data collection. Minimum sampling time shall be configurable with a minimum sample rate of once per second.
 1. B-ASC panels shall store point history files for all analog and binary inputs and outputs.
 2. Measured and calculated analog and binary data shall also be assignable to user-definable trends.
 3. Trend data shall be stored at the stand-alone B-ASC panels, and uploaded to hard disk storage automatically at pre-configured intervals when archival is desired. B-ASC shall be equipped with enough storage for a minimum of 24 hours of trend data.
- J. Stand-alone B-ASC panels shall automatically accumulate and store runtime hours for binary input and output points.

- K. B-ASC panels shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and binary pulse input-type points.
- L. B-ASC panels shall have the ability to count and/or execute events on a daily, weekly, or monthly basis.
- M. B-ASC for VAV ATUs application shall comply with the following:
1. B-ASC shall be provided with integral damper actuator. Actuator shall feature the following at a minimum:
 - a. 35 in-lbs of torque.
 - b. Brushless DC Operator.
 - c. Actual damper position feedback. Drive time or other software calculated damper position shall not be accepted.
 - d. Damper End Switch using motor current sense or equivalent for positive feedback of both end stop positions.
 - e. Software selectable rotation.
 2. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, 0-5VDC, and 0-10VDC.
 - b. Pulse accumulation shall accommodate a minimum frequency of 40Hz.
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
 - d. 24VAC over-voltage protection.
 3. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:
 - a. Universal Outputs shall provide configurable modulating signal to industry 0-5VDC, 0-10VDC, and 4-20 mA analog control devices and relays.
 - b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
 - c. Universal Output shall be capable of sourcing 75mA at 12VDC.
 - d. Outputs shall have a minimum 8 Bit D/A conversion resolution.
 - e. 24VAC over-voltage and short protection.
 4. Airflow Calibration, Test and Air Balance, etc. shall be performed via dedicated handheld configuration tool connected directly to communication port located at ATU B-ASC sensor. Special proprietary software and/or applications loaded on a computer, tablet or other similar device shall not be acceptable to perform this function.
 5. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits.
- N. B-ASC for unitary applications shall comply with the following:
1. B-ASC shall provide diagnostic LEDs for power, communications and processor status. The B-ASC shall continually check the status of its processor and memory circuits.
 2. Controller wiring terminals shall be removable terminal strips for ease of installation and service replacement.
 3. Universal field device hardware inputs shall be provided and configured on hardware and/or in software and comply with the following:
 - a. Inputs shall accept dry-contact, thermistor, 4-20 mA, and 0-5VDC.
 - b. Pulse accumulation shall accommodate a minimum frequency of 40Hz.
 - c. Inputs shall have a minimum 10 Bit A/D conversion resolution.
 - d. 24VAC over-voltage protection.
 4. Hardware Outputs shall be configured on hardware and/or in software and comply with the following:

- a. Universal Outputs shall provide configurable modulating voltage signal to industry 0-5VDC and 0-10VDC analog control devices and relays.
 - b. Each TRIAC Output shall source 500 mA current, 24 VAC 0.5 ACA.
 - c. Universal Output shall be capable of sourcing 75mA at 12VDC.
 - d. Outputs shall have a minimum 8 Bit D/A conversion resolution.
 5. 24VAC over-voltage and short protection.
- O. Control System Application Software:
1. The B-ASC application software shall be the same as and indistinguishable from the B-BC specified interaction with the Control System Application Software.
 2. The controller software shall reside in a real time, multi-tasking, networking operating environment. Database definition shall be accomplished through the B-AWS online with the B-ASC. The complete database and application program shall reside in the B-ASC. Configure the software to attain the proper sequence of control and to accomplish all other control system functions indicated in the Contract Documents.
 3. The user shall be able to add, delete, or modify objects on-line as required. The programming shall provide all the necessary mathematics, logic, utility and control functions necessary for proper sequence of control.
- P. Communications and Protocols
1. When connected to the Tier 2 network, the B-ASC shall communicate with field devices and controllers using the BACnet physical IP data link. The B-ASC shall support daisy chain, star, or IP ring topology as required.
 2. When connected to the Tier 3 network, The B-ASC shall communicate with field devices and controllers using the BACnet physical data link MS/TP at 76.8 Kbps where not limited by third party devices such as variable frequency drives, utility meters, etc.
 3. The B-ASC shall provide a communications port for connection of the Portable Operators Terminal using Point-to-Point BACnet physical data link layer protocol or a connection to the inter-network.
 4. B-ASC shall support, transmit, and receive of segmented messages.
- Q. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 7. Universal I/Os: Provide software selectable binary or analog outputs.
- R. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.

2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

2.7 ENCLOSURES AND SUB-PANELS

- A. Provide pedestal base or wall mounted local control enclosure to house all control components associated with each area, system or mechanical equipment room.
 1. The enclosures shall be minimum 16 gauge steel or aluminum, totally enclosed on all sides and painted with a baked enamel finish. All enclosures must maintain a minimum separation of 1" from the back wall.
 2. Enclosures located in wet indoor conditions or located outdoors shall meet NEMA 4X.
 3. Penetrations are permitted on bottom of enclosure only. Do not make conduit penetrations in top or side of enclosure. Each enclosure shall be equipped with a wire gutter below with a minimum of six ¾" minimum conduit penetrations into the bottom of the enclosure to accommodate system wiring.
 4. Where required by AHJ, enclosures located in mechanical or electrical rooms shall meet NEMA 2 requirements.
 5. Enclosures located in all other locations including but not limited to mechanical or electrical rooms not requiring NEMA 2, occupied spaces, above ceilings and plenums shall be the same NEMA classification as all other enclosures located in the same environment, except if location requires additional protection due to potential vandalism or environmental conditions and shall at a minimum meet NEMA 1 requirements.
 6. Enclosures provided as an integral (pre-packaged) part of another product and/or piece of equipment are acceptable.
 7. Provide a continuous piano hinged door, keyed locking latch and removable sub-panel. A single key shall be common to all control enclosures.
- B. Provide each DDC panel with a line filter, surge suppressor, electrical disconnect, control fuse, and control transformer.
- C. Provide power supplies located inside control enclosures shall be fully enclosed with external 24 Vac terminals, on/off control, equipment overcurrent protection, power indication, high/low voltage separation, and convenience 120VAC outlets.
- D. Provide insulated, modular, feed-through, clamp-style terminal blocks suitable for rail-mounting with end plates and partitions for the termination of all field wiring in control enclosures. Field wiring to equipment with integral terminals and/or unitary equipment (i.e., VAVs ATUs, EFs, &c.) shall not be required to have terminal blocks.
- E. Rail mounted terminal blocks shall be color coded to match the associated conductor colors.
- F. All DDC control enclosures and panels shall be permanently labeled with engraved plastic nameplates, white with black center cores.
- G.

2.8 TEMPERATURE SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Platinum RTDs: Common Requirements:
1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
 3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F (Minus 46 to 135 deg C).
 - b. Interchangeable Accuracy: At 32 deg F (zero deg C) within 0.5 deg F (0.3 deg C).
 - c. Repeatability: Within 0.5 deg F (0.3 deg C).
 - d. Self-Heating: Negligible.
 4. Transmitter Requirements:
 - a. Transmitter required for each 100-ohm RTD.
 - b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.
- C. Platinum RTD, Single-Point Air Temperature Duct Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Minco; S400 Series PD or PF.
 - b. BEC Controls Corporation.
 - c. MAMAC Systems, Inc.
 - d. RDF Corporation.
 2. 1000 ohms.
 3. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
 4. Probe: Single-point sensor with a stainless-steel sheath.
 5. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches ((450 mm) long).
 6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
 7. Gasket for attachment to duct or equipment to seal penetration airtight.
 8. Conduit Connection: 1/2-inch ((16-mm) trade size.)
- D. Platinum RTD, Air Temperature Averaging Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Minco; S400 Series PD or PF.
 - b. BEC Controls Corporation.
 - c. MAMAC Systems, Inc.
 - d. RDF Corporation.
 2. 1000 ohms.
 3. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
 4. Multiple sensors to provide average temperature across entire length of sensor.
 5. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
 6. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch (100-mm) radius.
 7. Length: As required by application to cover entire cross section of air tunnel.
 8. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.

9. Gasket for attachment to duct or equipment to seal penetration airtight.
 10. Conduit Connection: 1/2-inch (16-mm) trade size.)
- E. Platinum RTD Outdoor Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Minco; S400 Series PD or PF.
 - b. BEC Controls Corporation.
 - c. MAMAC Systems, Inc.
 - d. RDF Corporation.
 2. 1000 ohms.
 3. Temperature Range: Minus 50 to 275 deg F (Minus 45 to 135 deg C).
 4. Probe: Single-point sensor with a stainless-steel sheath.
 5. Solar Shield: Stainless steel.
 6. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
 7. Conduit Connection: 1/2-inch (16-mm) trade size.
- F. Platinum RTD Space Air Temperature Sensors:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Minco; S400 Series PD or PF.
 - b. BEC Controls Corporation.
 - c. MAMAC Systems, Inc.
 - d. RDF Corporation.
 2. 1000 ohms.
 3. Temperature Range: Minus 50 to 212 deg F ((Minus 45 to 100 deg C).)
 4. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
 5. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
 6. Concealed wiring connection.
- G. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:
1. 1000-ohm platinum RTD.
 2. Temperature Transmitter Requirements:
 - a. Mating transmitter required with each 100-ohm RTD.
 - b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
 3. Provide digital display of sensed temperature.
 4. Provide sensor with local control.
 - a. Local override to turn HVAC on.
 - b. Local adjustment of temperature set point.
 - c. Both features shall be capable of manual override through control system operator.
- H. Room sensor accessories include the following:
1. Insulating Bases: For sensors located on exterior walls.
 2. Sensor Protective Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.
 - a. Adjusting Key: As required for calibration and cover screws.
- I. Liquid Temperature Sensors
1. RTD, Commercial Grade:

- a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) Automation Components, Inc. (ACI)
 - 2) MAMAC Systems, Inc.
 - 3) Dwyer Instruments, Inc.
 - 4) Approved performance equal.
- 2. Description:
 - a. Platinum with a value of 100 or 1000 ohms at 0 deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 - b. Encase RTD in a stainless steel sheath with a 0.25-inch OD.
 - c. Sensor Length: 4, 6, or 8 inches as required by application.
 - d. Process Connection: Threaded, NPS 1/2.
 - e. Two-stranded copper lead wires.
 - f. Powder-coated steel enclosure, NEMA 250, Type 4.
 - g. Conduit Connection: 1/2-inch trade size.
 - h. Performance Characteristics:
 - 1) Range: Minus 40 to 210 deg F.
 - 2) Interchangeable Accuracy: Within 0.50 deg F at 32 deg F.
 - i. Thermowells, Commercial Grade:
 - 1) Stem: Straight shank formed from solid bar stock.
 - 2) Material: stainless steel.
 - 3) Process Connection: Threaded, NPS 3/4.
 - 4) Sensor Connection: Threaded, NPS 1/2.
 - 5) Bore: Sized to accommodate sensor with tight tolerance between sensor and well.
 - 6) Furnish thermowells installed in insulated pipes and equipment with an extended neck.
 - 7) Length: 4, 6, or 8 inches as required by application.
 - 8) Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.9 HUMIDITY SENSORS

- A. Humidity Sensors: Bulk polymer sensor element.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. Vaisala.
 - 2. Accuracy: 5 percent full range with linear output.
 - 3. Room Sensor Range: 20 to 80 percent relative humidity.
 - 4. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - a. Set-Point Adjustment: Concealed.
 - b. Set-Point Indication: Concealed.
 - c. Thermometer: Concealed.
 - d. Color: White.
 - e. Orientation: Vertical.
 - 5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.

6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F (minus 40 to plus 76 deg C).
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

2.10 PRESSURE SENSORS

1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - a. BEC Controls Corporation.
 - b. General Eastern Instruments.
 - c. MAMAC Systems, Inc.
 - d. ROTRONIC Instrument Corp.
 - e. Setra
 - f. Vaisala.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
 - d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).
3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

2.11 STATUS SENSORS

- A. Status Inputs for Fans:
 1. Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
 2. Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- B. Status Inputs for Pumps:
 1. Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
 2. Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
- D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

- E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
- F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- H. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
 - 1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - a. BEC Controls Corporation.
 - b. I.T.M. Instruments Inc.
- I. Low Temperature Switch for Duct Applications:
 - 1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - a. Johnson Controls
 - b. Siemens
 - c. Approved performance equal.
 - 2. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 3. Performance:
 - a. Operating Temperature Range: 15 to 55 deg F.
 - b. Temperature Differential: 5 deg F, non-adjustable and additive.
 - c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
 - d. Sensing Element Maximum Temperature: 250 deg F.
 - e. Voltage: 120-V ac.
 - f. Current: 16 FLA.
 - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.
 - 4. Construction:
 - a. Vapor-Filled Sensing Element: Nominal 20 ft long.
 - b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 1/2-inch trade size.

2.12 OCCUPANCY SENSORS

- A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:

1. Veris
 2. Kele
 3. Approved performance equal.
- B. Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.
- C. General Requirements for Sensors:
1. Sensor Operation: Unless otherwise indicated, operate HVAC according to occupied mode when covered area is occupied and operate HVAC according to unoccupied mode when unoccupied; with a time delay for turning off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20 A load at 120 and 277 Vac. Power supply to sensor is to be 24 V dc, 150 mA, Class 2 power source as defined by NFPA 70.
 4. DDC System Connection: Hardwired.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position in a standard device box or outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knock out in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Indicator: Digital display, to show when motion is being detected during testing and normal operation of the sensor.
 7. Bypass Switch: Override the on function in case of sensor failure.
 8. Listed and labeled in accordance with NFPA 70, by a qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- D. Motion Sensors - Passive Infrared: Ceiling or wall mounting; detect occupancy by sensing a combination of heat and movement in coverage area.
1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
 2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
 3. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 sq. ft. when mounted 48 inches above finished floor.
 4. Detection Coverage (Corridor, Ceiling Mounted): Detect occupancy within 90 ft. when mounted on a 10-foot-high ceiling.
 5. Actual sensor quantity and placement shall be verified during installation and commissioning to ensure complete zone coverage. Additional sensors shall be provided as required to eliminate detection gaps caused by room geometry, furnishings, partitions, or other obstructions.
- 2.13 CARBON MONOXIDE SENSORS

- A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
1. MSA

2. Armstrong Monitoring
 3. Greystone Energy Systems, Inc.
 4. Honeywell
 5. Intec Controls, Inc.
 6. Dwyer
 7. Approved performance equal.
- B. Description: Electrochemical measurement technology or equivalent technology that provides performance indicated, long-term stability, and reliability. Sensors with a 3-year minimum life.
1. Individual Sensor/Transmitter Applications: Each sensor/transmitter connected directly to DDC system.
 2. Multiple Sensor/Transmitters for Zoned Applications: Multiple sensor/transmitters arranged in zones as indicated on Drawings and directly connected to carbon monoxide monitoring system controller; furnished with sensors and transmitters as part of a complete system furnished by single manufacturer.
- C. Performance:
1. Carbon Monoxide Concentration Range: Zero to 100 ppm.
 2. Accuracy: Within 5 percent of full-scale range.
 3. Ambient Temperature: 0 to 104 deg F.
- D. Sensor and Transmitter Output Signals:
1. Analog Output Signal: 4 to 20 mA.
 2. 2 factory-calibrated alarm levels at 50 and 100 ppm
- E. Sensor and Transmitter Construction:
1. Enclosure: Painted metal or plastic
 2. Electrical Connections: Screw terminals
- F. Calibration Kit: Provide kit and turn over to Owner at start of warranty period.
- 2.14 CARBON DIOXIDE SENSORS
- A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
1. Vaisala
 2. Armstrong Monitoring
 3. Greystone Energy Systems, Inc.
 4. Honeywell
 5. Intec Controls, Inc.
 6. Veris
 7. Approved performance equal.
- B. Description:
1. NDIR or equivalent technology that provides performance indicated, long-term stability, and reliability.
- C. Performance:
1. Carbon Dioxide Concentration Range: Zero to 2000 ppm.
 2. Accuracy: Within 3 percent of reading, plus or minus 40 ppm.
 3. Response Time: Within 60 seconds.

4. Warm-up Time: Within 3 minute(s).
5. Ambient Relative Humidity: Zero to 95 percent noncondensing.
6. Ambient Temperature: 32 to 122 deg F.

D. Output Signals:

1. Analog Output Signal: 4 to 20 mA output signal, linearized to carbon dioxide concentration in parts per million (ppm).

E. Construction:

1. Enclosure: Painted metal or plastic.
2. Electrical Connections: Screw terminals.

F. Calibration Kit: Provide kit and turnover to Owner at start of warranty period.

2.15 OXYGEN SENSORS

A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:

1. PureAire
2. MSA
3. Honeywell
4. Armstrong Monitoring
5. Intec Controls, Inc.
6. Approved performance equal.

B. Description: Single wall mounted detector using long-life zirconium oxide sensor cell or electrochemical sensor technology that provides performance indicated, long-term stability, and reliability.

C. Performance:

1. Oxygen Concentration Range: Zero to 25%.
2. Accuracy: Within 1 percent of full-scale range.
3. Ambient Temperature: Minus 40 to 140 deg F.

D. Sensor and Transmitter Output Signals:

1. Analog Output Signal: 4 to 20 mA.
2. 2 SPDT relay contacts

E. Sensor and Transmitter Construction:

1. Enclosure: Painted metal or plastic

F. Installation Requirements:

1. Mounting Height: 4 to 5 feet above finished floor (breathing zone height).
2. Alarm Devices: Provide strobe light and horn outside monitored space. Strobe must be visible from 50 feet; horn must be ≥ 90 dB at 10 feet.
3. Alarm Activation: Triggered when oxygen level falls below 19.5%.
4. Alarm Reset: Automatic reset when oxygen levels normalize.
5. Signage: Install EHRS-approved signage on all entry doors indicating potential oxygen deficiency hazard.

2.16 REFRIGERANT VAPOR DETECTION SYSTEM

- A. Provide a refrigerant vapor detection system to meet the latest version of ASHRAE 15 and the applicable local codes. The system shall sample and monitor a minimum of two (2) remote sampling points per Chiller.
- B. Provide the following accessories:
 - 1. One alarm relay for each level of alarm and one relay for flow failure or horn silence. Failure relay output that shall energize upon failure of monitor system operation. Failures include but are not limited to the following: low airflow through monitor, power circuit failure, and a saturated or absent sensor signal.
 - 2. Analog Output 4-20 mA or 0-5 VDC.
 - 3. Enclosure type: NEMA 4X.
- C. Sampling Tubing shall be Type L or hard drawn copper tubing.
- D. The read out/control unit shall be wall mounted pursuant with contract drawings. Remote sampling points shall be located within the central plant area according to the drawings.

2.17 LIQUID LEAK DETECTION SWITCHES

- A. Point-Type, Leak-Detection Switches:
 - 1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - a. Kele
 - b. Bapi
 - c. Greystone
 - d. Approved performance equal.
 - 2. Features:
 - a. Alarms: Visual alarm with relay output for remote indication.
 - b. Operation: Alarm activation based on detection of liquid by change in resistance.
 - 3. Performance:
 - a. Field Power: 24 V ac or dc.
 - b. Service: Water.
 - c. Temperature Limits: 32 to 122 deg F.
 - d. Sensing Height: Adjustable.
 - 4. Construction:
 - a. Enclosure: Acrylic, ABS plastic or painted metal.
 - b. Switch Type: SPDT relay.
- B. Cable-Type, Leak-Detection Switches:
 - 1. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - a. Kele
 - b. Bapi
 - c. Greystone
 - d. Approved performance equal.
 - 2. Control Module Features:
 - a. Power and alarm LEDs.
 - b. Continuous cable integrity self-check.

3. Performance:
 - a. Service: Water or other conductive liquid.
 - b. Switch Type: 2 SPDT relays
4. Construction:
 - a. Control Module Enclosure: Painted metal.
 - b. Cable: Hydrophobic.
 - c. Cable Length: As required by application.
5. Field Power: 24 V ac or 24 to 30 V dc unless otherwise required by application.

2.18 WATER FLOW METERS

- A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 1. Onicon F-3200 Series
 2. Approved performance equal.
- B. Description: In-line body flow meter using electromagnetic technology.
 1. No moving parts.
 2. Continuous auto-zero function.
 3. Inherent bidirectional flow measurement.
 4. Flow-measurement applications with three pipe diameters upstream and two pipe diameters downstream.
- C. Factory Calibration: Wet calibrate each meter to standards traceable to NIST. Tag each meter and provide each meter with a certificate of calibration.
- D. Performance:
 1. Ambient Temperature: Minus 4 to plus 140 deg F.
 2. Conductivity: Suitable for flow measurement of fluids with electrical conductivity greater than 5 microseimens per centimeter.
 3. Flow Velocity Range: 0.1 to 33 fps.
 4. Flow Accuracy: Within 0.2 percent of reading for flow velocities between 1.6 to 33 fps and within 0.0033 fps of reading for flow velocities 1.6 fps and less.
 5. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
 6. Pressure Drop: No permanent pressure drop.
- E. Analog Output Current Signal:
 1. Two-wire, 4 to 20 mA dc current source.
 2. Digital Output Signal: Two, programmable, digital/pulse outputs configurable for frequency, pulse, or directional flow.
 3. Communication Interface: BACnet IP or BACnet MS/TP capable with associated flow meter display.
 4. Operator Interface: Keypad with backlit digital display.
 - a. Each flow meter shall be factory programmed for its specific application, and shall be re-programmable using the integral keypad on the converter (no special interface device or computer required). Each flow meter shall be covered by the manufactures two-year warranty.
 5. Multiple-line digital display of alphanumeric characters.
 6. LED for normal and alarm operation.

F. Construction:

1. Body Material: Epoxy-coated carbon steel.
2. PTFE body liner offers better performance over larger size and temperature range. Consult manufacturer for other liner options.
3. Body Liner Material: Polypropylene or Ebonite for low temperature service, PTFE for hot water service.
4. Flow Tube Material: Type 304 or 316 stainless steel.
5. Body End Connections: ASME B16.5, Class 150 or 300 as required by pressure and temperature.
6. Electrodes: Type 316 stainless steel. Quantity determined by manufacturer based on application.
7. Electronics Enclosure:
 - a. Location: Integral or remote from meter body.
 - b. Material: Painted aluminum.
 - c. Removable cover.
 - d. Rating: NEMA 250, Type 4, 4X, or 6.
8. For installations in non-metallic pipe, install grounding rings between flanges.

2.19 HYDRONIC THERMAL ENERGY (BTU) METERS

A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:

1. Onicon System-10
2. Approved performance equal.

B. Description:

1. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, keypad user interface, installation hardware, color-coded interconnecting cabling, and installation instructions.
2. Factory calibrate each thermal energy meter and provide with calibration certification traceable to NIST.

C. Performance:

1. Ambient Operating Temperature: Minus 20 to plus 140 deg F.
2. Energy Calculation Nonlinearity: Within 0.05 percent.
3. Fluid Electrical Conductivity: Suitable for fluids with electrical conductivity greater than 5 microseimens per centimeter.
4. Flow Sensor: Refer to Section "WATER FLOW METERS" for flow sensor requirements.
5. Process Pressure and Temperature: Suitable for system maximum operating pressure and temperature.
6. Process Temperature Accuracy: Differential temperature accuracy within 0.15 deg F over the calibrated range.

D. Meter Display: Backlit, LCD alphanumeric display of the following on face of meter enclosure:

1. Total energy consumption.
2. Energy rate.
3. Flow rate.
4. Supply temperature.
5. Return temperature.

6. Visual indication of power status (on/off) on face of enclosure.
- E. Meter Electronics Enclosure:
 1. Remote mounted from temperature and flow sensors.
 2. Indoor Applications: NEMA 250, Type 4 or 13.
 3. Outdoor Applications: NEMA 250, Type 4.
 4. Labeled terminal strip for field wiring connections.
 5. Connections: Suitable for mating to field-installed conduit.
 - F. Power Supply:
 1. Field Power: 24, 120, 240 V ac, 50 or 60 Hz as required by the application.
 2. Internal Power: As required by flow meter.
 - G. Programming:
 1. Factory programmed for specific application and field programmable through keypad on face of enclosure.
 2. Programmed parameters and total energy consumption stored in non-volatile EEPROM memory.
 - H. Output Signals:
 1. Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50 V rating and contact duration of 0.5, 1, 2, or 6 seconds.
 2. Energy Rate, Flow Rate, Supply Temperature, Return Temperature: 4 to 20 mA or zero to 10 V dc for each.
 3. Communication Interface: BACnet IP or BACnet MS/TP capable to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
 - I. Temperature Sensors:
 1. Enclosure: NEMA 250, Type 4 with conduit connections.
 2. Sensor Cable: As required by manufacturer for application.
 3. Temperature Range: Matched pair; suitable for application.
 4. Thermowells: Stainless steel; with NPT
- 2.20 DUCT AIR FLOW MEASURING STATIONS
- A. Manufacturers, Subject to compliance with requirements, provide products by one of the following:
 1. EBTRON, Inc.
 2. Onicon Incorporated.
 3. Approved performance equal.
 - B. General:
 1. Provide an EBTRON, Inc. model GTx116-P+ duct airflow measuring station.
 2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
 - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
 3. Substitution requests for acceptance less than 60 days prior to bid date or products submitted in non-conformance with the requirements of this specification will not be considered.

- a. For any product to be considered for substitution, a written document shall be submitted to the engineer detailing exceptions and compliance, section-by-section with supporting documentation, before an approval will be considered.
 - b. Any product submitted as an equal shall be expected to comply with all performance capabilities and functional aspects of this specification.
- 4. Excluded devices
 - a. Fan Inlet airflow measurement devices.
 - b. Measurement technologies using chip-in-glass, chip-in-epoxy or other chip type thermistors for the heated sensor component are not acceptable.
 - c. Pitot tubes, Pitot arrays, Piezo rings and other differential pressure based devices are not acceptable.
 - d. Vortex shedding devices are not acceptable.
- C. Required product performance:
 - 1. Airflow Measurement Devices (AMD) with Temperature Output and Airflow Alarming Capability
 - 2. General
 - a. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
 - b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
 - 1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
 - c. Airflow measurement shall be field configurable to determine the average Actual or Standard mass airflow rate.
 - 1) Actual airflow rate calculations shall have the capability of being corrected by the transmitter for altitudes other than sea level.
 - d. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature.
 - 3. Sensor Probes
 - a. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube, 316 stainless steel tube are available when required.
 - b. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
 - c. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.
 - 1) PVC jacketed internal wiring is not acceptable.
 - d. Probe internal wiring connections shall consist of solder joints and spot welds.
 - 1) Internal wiring connections shall be sealed and protected from the elements. They shall be capable of direct exposure to water without affecting instrument operation.
 - 2) Connectors of any type within the probe are not acceptable.
 - 3) Printed circuit boards within the probe are not acceptable.
 - e. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67° F to 392° F (-55° C to 200° C) and continuous and direct UV exposure.
 - 1) Plenum rated PVC jacket cables are not acceptable.
 - f. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
 - g. Each sensor probe shall contain one or more independently wired sensing nodes.

- h. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter in the field.
 - i. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Upon request, the manufacture shall provide a written independent laboratory test result of 100% survival rate in a 30 day saltwater and acid vapor test.
 - 1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
 - 2) Devices with exposed leads are not acceptable.
 - j. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
 - k. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of $\pm 2\%$ of reading over the entire calibrated airflow range of 0 to 5,000 FPM (25.4 m/s).
 - 1) Upon request the manufacture shall submit for AMD approval a copy of the NIST report of calibration used for the reference standard used.
 - a) Devices claiming NIST traceability to third party laboratories and not directly to NIST are not acceptable.
 - b) Devices calibrated against standards other than the NIST LDA are not acceptable.
 - l. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
 - m. The installed airflow accuracy shall be:
 - 1) Ducts - $\pm 3\%$ of reading when installed in accordance with the manufactures recommended placement guidelines.
 - 2) Non-ducted Outdoor Air intakes better than or equal to $\pm 5\%$ of reading when installed in accordance with the manufactures recommended placement guidelines.
 - n. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
 - o. Each sensing node shall have a temperature accuracy of $\pm 0.15^\circ \text{F}$ (0.08°C) over an operating range of -20°F to 160°F . (-28.9°C to 71.1°C) and humidity range of 0 to 100% RH.
4. Transmitter
- a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
 - b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
 - c. All printed circuit board interconnects, edge fingers, receptacle plug pins and PCB test points shall be gold plated.
 - d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
 - e. All integrated circuitry shall be temperature rated as industrial-grade. Submissions containing commercial-grade integrated circuitry are not acceptable.
 - f. The transmitter shall be capable of determining the airflow rate and temperature average of all connected sensor nodes in an array for a single location.

- 1) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
- g. The transmitter shall be capable of providing a high and/or low airflow alarm with user-defined set point and % of set point tolerance. Alarm shall be capable of being manually or automatically reset and low-limit cutoff value may be selected to disable the alarm. An alarm delay function shall also be field defined.
- h. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
- i. The transmitter shall be capable of field configuration, diagnostics and include Field Output Adjustment Wizard that allows for a one or two point field adjustment to factory calibration for installations that require adjustment.
- j. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
- k. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals (AO1=airflow, AO2=temperature or alarm), in combination with either of the following:
 - 1) one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection
 - 2) one isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection
- l. The analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate and the second output (AO2) shall be field configurable to provide temperature information.
- m. The transmitter shall also be available with a single isolated LonWorks Free Topology network interface. Transmitters shall be available alternatively with one USB connection for thumb-drive data logging of sensor data. Neither of these options shall include analog output signals.
- n. The network communications RS-485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, hi and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures. Individual node airflow rates and temperatures shall NOT be available via the network with Lon.
- o. The transmitter shall have an on-off power switch. Isolation transformers shall not be required.
- p. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @20 V-A maximum and use a switching power supply that is over-current and over-voltage protected.
- q. The transmitter shall use a watchdog timer circuit to ensure automatic reset after power disruption, transients and brown-outs.
- r. Each transmitter shall have an operating temperature range of -20° F to 120° F (-28.9° C to 48.9° C) and humidity range of 5 to 95% RH.
5. Listings and Certifications
 - a. The AMD shall be UL/cUL 873 Listed as an assembly.
 - 1) Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
 - b. All network-capable AMD models supplied with RS-485 interface and BACnet protocol shall be BTL Listed.

- c. The AMD shall be tested for compliance with the EMC Directive's requirements and be certified to carry the CE Mark for European Union Shipments.
- 6. Installation
 - a. Install in accordance with manufacturer's placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

2.21 FAN AIR FLOW MEASURING STATIONS

- A. Manufacturers; Subject to compliance with requirements, provide products by one of the following:
 - 1. EBTRON, Inc.
 - 2. Onicon Incorporated.
 - 3. Approved performance equal.
- B. General
 - 1. Provide an EBTRON, Inc. model GTx108-F fan airflow measuring device.
 - 2. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
 - a. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
 - 3. Substitution requests for acceptance less than 60 days prior to bid date or products submitted in non-conformance with the requirements of this specification will not be considered.
 - a. For any product to be considered for substitution, a written document shall be submitted to the engineer detailing exceptions and compliance, section-by-section with supporting documentation, before an approval will be considered.
 - b. Any product submitted as an equal shall be expected to comply with all performance capabilities and functional aspects of this specification.
 - 4. Excluded devices
 - a. Fan Inlet airflow measurement devices.
 - b. Measurement technologies using chip-in-glass, chip-in-epoxy or other chip-type thermistors for the heated sensor component are not acceptable.
 - c. Pitot tubes, Pitot arrays, Piezo rings and other differential pressure based devices are not acceptable.
 - d. Vortex shedding devices are not acceptable.
- C. Required product performance
 - 1. Airflow Measurement Devices (AMD) with Temperature Output and Airflow Alarming Capability
 - 2. General
 - a. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
 - b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.
 - 1) Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
 - c. Airflow measurement shall be field configurable to determine the average Actual or Standard mass airflow rate.

- 1) Actual airflow rate calculations shall have the capability of being corrected by the transmitter for altitudes other than sea level.
- d. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature
3. Sensor probes
 - a. Sensor probes shall consist of one sensor node mounted on a 304 stainless steel block with two adjustable zinc plated steel rods connected to 304 stainless steel pivoting mounting feet.
 - b. Sensor node internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
 - c. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392 °F (-55° C to 200° C) and continuous and direct UV exposure.
 - 1) Plenum rated PVC jacket cables are not acceptable.
 - d. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
 - e. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter in the field.
 - f. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Upon request, the manufacture shall provide a written independent laboratory test result of 100% survival rate in a 30 day saltwater and acid vapor test.
 - 1) Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
 - 2) Devices with exposed leads are not acceptable.
 - g. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
 - h. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of $\pm 2\%$ of reading over the entire calibrated airflow range of 0 to 10,000 FPM (50.8 m/s).
 - 1) Upon request the manufacture shall submit for AMD approval a copy of the NIST report of calibration used for the reference standard used.
 - a) Devices calibrated against standards other than the NIST LDA or against NIST temperature standards only are not acceptable.
 - 2) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
 - 3) Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
 - i. Each sensing node shall have a temperature accuracy of $\pm 0.15^\circ \text{ F}$ (0.08° C) over an operating range of -20° F to 160° F (-28.9° C to 71.1° C) and humidity range of 0 to 100% RH.
 - j. The number of independent sensor nodes provided shall be as follows:
 - 1) SWSI and DWDI fans: 2 probes x 1 sensor node/per probe in each fan inlet
 - 2) Fan Arrays (1 to 8 fans): 2 probes x 1 sensor node probe in each fan inlet
4. Transmitter
 - a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.

- b. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
- c. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
- d. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
- e. All integrated circuitry shall be temperature rated as industrial-grade. Submissions containing commercial-grade integrated circuitry are not acceptable.
- f. The transmitter shall be capable of determining the airflow rate and temperature of each fan
 - 1) Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
- g. The transmitter shall have startup firmware to facilitate setup of multiple fans and fan areas.
- h. The transmitter shall be capable of providing a low and/or high airflow set point alarm.
- i. The transmitter shall be capable of providing individual fan alarming on fan array configurations.
- j. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
- k. The transmitter shall be capable of field configuration, diagnostics and include Field Output Adjustment Wizard that allows for a one or two point field adjustment to factory calibration for installations that require adjustment.
- l. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
- m. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals (AO1=airflow, AO2=temperature or alarm), in combination with either of the following:
 - 1) One isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection
 - 2) One isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection
- n. Analog signal capability shall include two output terminals: the first (AO1), shall provide the total airflow rate; while the second output (AO2) shall be field configurable to provide temperature.
- o. The transmitter shall also be available with a single isolated LonWorks Free Topology network interface. Transmitters shall be available alternatively with one USB connection for thumb-drive data logging of sensor data. Neither of these options shall include analog output signals.
- p. Network communications RS 485 (BACnet MS/TP or Modbus RTU) or Ethernet (BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) shall provide: the average airflow rate, temperature, hi and/or low airflow set point alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures. Individual node airflow rates and temperatures shall be available via the network with Lon.
- q. The transmitter shall have an on-off power switch. Isolation transformers shall not be required.

- r. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @16 V-A maximum and use a switching power supply that is over-current and over-voltage protected.
- s. The transmitter shall use a watchdog timer circuit to ensure automatic reset after power disruption, transients and brown-outs.
- t. Each transmitter shall have an operating range of -20° F to 120° F (-28.9° C to 48.9° C) and humidity range of 5 to 95% RH.
- 5. Listing and Certifications
 - a. The AMD shall be UL/cUL 873 Listed as an assembly;
 - 1) Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
 - b. All network-capable AMD models supplied with RS-485 interface and BACnet protocol shall be BTL Listed
- 6. Installation
 - a. Install in accordance with manufacturer's placement guidelines. A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.

2.22 THERMOSTATS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Erie Controls.
 - 2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
 - 3. Heat-Timer Corporation.
 - 4. Honeywell Controls.
 - 5. Sauter Controls Corporation.
 - 6. tekmar Control Systems, Inc.
 - 7. Theben AG - Lumilite Control Technology, Inc.
- B. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
 - 1. Automatic switching from heating to cooling.
 - 2. Preferential rate control to minimize overshoot and deviation from set point.
 - 3. Set up for four separate temperatures per day.
 - 4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
 - 5. Short-cycle protection.
 - 6. Programming based on every day of week.
 - 7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
 - 8. Battery replacement without program loss.
 - 9. Thermostat display features include the following:
 - a. Time of day.
 - b. Actual room temperature.
 - c. Programmed temperature.
 - d. Programmed time.
 - e. Duration of timed override.
 - f. Day of week.
 - g. System mode indications include "heating," "off," "fan auto," and "fan on."

- C. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
- D. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.
 - 1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
 - 2. Selector Switch: Integral, manual on-off-auto.
- E. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
 - 1. Bulbs in water lines with separate wells of same material as bulb.
 - 2. Bulbs in air ducts with flanges and shields.
 - 3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
 - 4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 - 5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
 - 6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

2.23 HUMIDISTATS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. MAMAC Systems, Inc.
 - 2. ROTRONIC Instrument Corp.
- B. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

2.24 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belimo Aircontrols (USA), Inc.
 - b. Siemens.
 - c. Johnson Controls.
 - d. Alerton.
 - e. Delta Controls.
 - f. IMI TA / Victaulic.
 - 2. Comply with requirements in Section 23 0513 "Common Motor Requirements for HVAC Equipment."

3. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 4. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 5. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 6. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 7. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 8. Combination Fire Smoke Dampers:
 - a. Size for torque required for damper seal at load conditions.
 - b. Coupling: V-bolt dual nut clamp with a V-shaped toothed cradle. Aluminum clamps or set screws are not acceptable.
 - c. Overload Protection: Microprocessor or an electronic based motor controller providing burnout protection if stalled before full rotation is reached. The actuator shall be electronically cut off at full open to eliminate noise generation with the holding noise level to be inaudible.
 - d. Power Requirements: 0.23A (running) and 0.09A (holding) at 24V-ac or 27 VA (running) and 10 VA (holding) at 120V-ac.
 - e. Actuator timing shall be 15 seconds or as required by local codes, whichever is more stringent.
 - f. Temperature Rating: Actuator shall have UL555 and UL555S listings by the damper manufacturer for 350°F.
 - g. Proportional Combination Fire and Smoke Damper Actuators shall meet all requirements specified above and shall modulate 0-100% open in response to a 2-10vdc or 4-20mA control signal. A 2-10vdc feedback output shall provide a 2-10vdc signal for position indication.
 - 1) Power Requirements (Proportional): Maximum (running) 12 VA at 24-V ac or 8 W at 24-V dc. Maximum (holding) 5VA at 24-V ac or 3 W at 24-V dc.
 - 2) A manual override winder and locking mechanism shall be provided for override operation of the actuator on a loss of power.
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belimo Aircontrols (USA), Inc.
 - b. Honeywell Controls Inc.
 2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
 3. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.

- d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
- e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
- f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
- 4. Coupling: V-bolt and V-shaped, toothed cradle.
- 5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
- 6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
- 7. Power Requirements (Two-Position Spring Return): 24 or 120]-V ac.
- 8. Power Requirements (Modulating): Maximum 25 VA at 24-V ac or 8 W at 24-V dc.
- 9. Proportional Signal: 0- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
- 10. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C).
- 11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
- 12. Run Time: 12 seconds open, 5 seconds closed.
- 13. The manufacturer shall provide 5-year limited warranty from the date of sale covering defects in material or workmanship.
- 14. All actuators are to be delivered with a detailed written installation instruction.

2.25 CONTROL VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belimo Aircontrols (USA), Inc.
 - 2. Siemens.
 - 3. Johnson Controls.
 - 4. Schneider Electric.
 - 5. IMI TA / Victaulic Modulator, Fusion P, Compact P.
- B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- C. Hydronic System Characterized Ball valves shall have the following characteristics:
 - 1. 2" and Smaller: Nickel-plated forged brass body rated at no less than 400 psi, stainless steel ball and blowout proof stem, female NPT end fittings, with a dual EPDM O-ring packing design, fiberglass reinforced Teflon seats, and a TEFZEL or stainless steel flow characterizing disc.
 - 2. 2-1/2" through 6" : GG25 cast iron body, ANSI 125, class B, stainless steel ball and blowout proof stem, flange to match ANSI 125 with a dual EPDM O-ring package design, PTFE seats, and a stainless steel flow characterizing disc.
 - 3. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
 - 4. Sizing: 5-psig (35-kPa) maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Twice the load pressure drop, but not more than value specified above.

- c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 - 5. Valve assemblies shall be maintenance free.
- D. Hydronic System Globe valves shall have the following characteristics:
 - 1. NPS 2 (DN 50) and Smaller: Class 250 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with back-seating capacity re-packable under pressure.
 - 2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
 - 3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
 - 4. Sizing: 5-psig (35-kPa) maximum pressure drop at design flow rate or the following:
 - a. Two Position: Line size.
 - b. Two-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 - c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
 - 5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 - 6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
 - 7. Two- and three-way globe valves shall be used only if characterized control valves do not fit the sizing criteria or application.
- E. Hydronic System Butterfly Valves: Resilient Seat shall have the following characteristics:
 - 1. NPS 2 to 12: Valve body shall be full lugged ductile iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize an internal spline. The shaft shall be supported at four locations by RPTFE bushings. A coated disc shell is not acceptable.
 - 2. NPS 14 and Larger: Valve body shall be full lugged ductile iron 200 psig body with a 304 stainless steel disc, EPDM seat, extended neck and shall meet ANSI Class 125/150 flange standards. Disc-to-stem connection shall utilize a dual-pin method to prevent the disc from settling onto the liner. The shaft shall be supported at four locations by RPTFE bushings. A coated disc shell is not acceptable.
 - 3. Sizing: Two-Position (on/off) butterfly valves shall be sized using the 90° Cv rating. Modulating butterfly valves shall be sized using the 60° Cv rating.
 - a. Maximum pressure drop shall not exceed 5-psig at design flow rate.
 - 4. Flow Characteristics: Modified equal percentage, unidirectional dead end service.
 - 5. Close-Off Pressure Rating: Bubble-tight shutoff (no leakage).
 - 6. The combination of two 2-way butterfly valves in a tee configuration cross-linked to ensure proper flow orientation shall be permitted. The tee shall be constructed of cast iron/stainless steel.
- F. Hydronic system Butterfly Valves - High Performance shall have the following characteristics:

1. Valve body shall be full lugged carbon steel ANSI Class 150 body with a 316 stainless steel disc without a nylon coating, RTFE seat, and be ANSI Class 150300 flange standards. Blowout-proof shaft shall be 17-4ph stainless steel and shall be supported at four locations by glass-backed TFE bushings. Valve packing shall be Chevron TFE and shall include fully adjustable packing flange and separable packing gland. Valve body shall have long stem design to allow for 2" insulation (minimum). Valve face-to-face dimensions shall comply with API 609 and MSS-SP-68. Valve assembly shall be completely assembled and tested, ready for installation.
 2. Sizing: Two-Position (on/off) butterfly valves shall be sized using the 90° Cv rating. Modulating butterfly valves shall be sized using the 60° Cv rating.
 - a. Maximum pressure drop shall not exceed 5-psig at design flow rate.
 3. Flow Characteristics: Modified equal percentage, full rated, bi-directional, dead end service with either flange removed.
 4. Close-Off Pressure Rating: Bubble-tight shutoff (no leakage).
 5. Media Temperature Range: ANSI Class 150 limitations.
 6. Max Differential Pressure: 285 psi @ 100 deg F for ANSI 150.
 7. The combination of two 2-way butterfly valves in a tee configuration cross-linked to ensure proper flow orientation shall be permitted. The tee should be constructed of cast iron/stainless steel.
- G. Hydronic Systems Pressure Independent Characterized Ball valves (Belimo) shall have the following characteristics:
1. ¾" and Smaller: Forged brass body rated at no less than 360 psi; stainless steel ball and blowout proof stem; female NPT end fittings, with a dual EPDM O-ring packing design; fiberglass reinforced Teflon seats and a stainless steel characterizing disc. An integral pressure regulator shall be located upstream of the ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig. Two internal P/T ports shall be incorporated for differential pressure verification. Replaceable cartridges are not permitted.
 2. 1" though 2": Forged brass body rated at no less than 360 psi; stainless steel ball and blowout proof stem; female NPT end fittings, with a dual EPDM O-ring packing design; fiberglass reinforced Teflon seats and a stainless steel or TEFZEL characterizing disc. An ultrasonic flow sensor (accuracy +/- 2%) shall be integrated with the characterized control valve to provide analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psig. The control valve assembly shall incorporate an algorithm to automatically compensate for the glycol concentration.
 3. 2-1/2" through 6": Cast iron body ANSI 125, Class B rated; stainless steel ball and blowout proof stem; pattern to mate with ANSI 125 flange, with a dual EPDM O-ring packing design; fiberglass reinforced Teflon seats and a stainless steel or TEFZEL characterizing disc. An ultrasonic flow sensor (accuracy +/- 2%) shall be integrated with the characterized control valve to provide analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psig. The control valve assembly shall incorporate an algorithm to automatically compensate for the glycol concentration.
 4. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
 5. Sizing: 5-psig maximum pressure drop at design flow rate.
 6. Valve assemblies shall be maintenance free.

H. Pressure Independent Control Valves (PICV/PICCV)

1. For accurate measurement for balancing, differential pressure control, trouble shooting, and power measurement in hydronic systems. Valve shall allow for adjustable flow settings, with valve and actuators supplied together ensuring optimum control performance.
2. NPS ½ through NPS 2: valves shall be suitable for working pressures to 230 ps and water temperature range of 32°F through +250°F. Valve shall consist of an Ametal (dezincification resistant alloy) / Stainless steel body and valve plug, EPDM spindle seal and O-rings, with seat seal of EPDM / stainless steel. The valve shall include stainless steel springs and spindles.
3. NPS 2-1/2 through NPS 6: valves shall be suitable for working pressures to 365 psi and water temperature range of +/-4°F through +250°F. shall consist of a ductile iron body and stainless steel valve plug, EPDM O-rings, with seat seal of EPDM/stainless steel.
4. Modulating Control: Valve shall be designed to operate with factory-provided actuator and have equal percentage (or EQM) control valve characteristic
5. Valve Actuator: Digitally configurable actuator for use with valve.
6. Sizing: 5-psig (35-kPa) maximum pressure drop at design flow rate or line size
7. Control Characteristics: Adjustable Cv, ability to measure flow through valve and deactivate DP portion of valve. Normally closed actuators shall be available factory installed.

I. Bypass and Injection Control Valves

1. Approved Manufacturer: Valve shall be VSI Series V - High Performance Segmented Ball Valve equipped with a Series 1000-X Electric Actuator. No substitutions permitted.
2. Valve Construction:
 - a. Close-Off Pressure Rating: Up to 250 psi for valves 1-6", and 285 psi for valves 8-12".
 - b. Operating Temperature Range: -20°F to 400°F.
 - c. Body: carbon steel or stainless steel.
 - d. Ball: 304 stainless steel.
 - e. Shaft: 304 stainless steel.
 - f. Seat: TFM 1700
 - g. Sealing components shall include ALFAS O-rings.
3. Sizing: Valves shall be sized to ensure a pressure drop between 3 psi and 6 psi at the design flow rate, unless otherwise noted on the drawings.
4. Flow Characteristic: Equal percentage.
5. Valve Actuator: Actuators shall be of the quarter turn type with a compact low-profile design to minimize space requirements. Valve actuators shall be digitally configurable and compatible with the valve for seamless integration and control. Valve actuators shall provide a minimum resolution of 200 discrete steps to ensure high-precision modulation and stable control performance.

2.26 DAMPERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Air Balance Inc.
2. TAMCO (T. A. Morrison & Co. Inc.).
3. Vent Products Company, Inc.

- B. Dampers: AMCA-rated, opposed-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 3. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.27 RELAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Functional Devices
 2. ROTRONIC Instrument Corp.
 3. Approved performance equal.
- B. General Requirements:
1. UL listed.
 2. Rated for at least 10 A at 250 V ac and 60 Hz.
 3. SPDT, DPDT, or three-pole double-throw, as required by control application.
 4. Construct contacts of silver, silver alloy, or gold.
 5. Enclose relay in a polycarbonate dust-tight cover.
 6. Include LED indication.
 7. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Ambient Operating Temperatures: Minus 30 to 115 deg F.
 8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
 9. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
 10. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers

2.28 CONTROL WIRE AND CABLE

- A. Wire: Single conductor control wiring above 24 V.
1. Wire Size: Minimum 14 AWG.
 2. Conductors: 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
 3. Conductor Insulation: 600 V, Type THWN or Type THHN, and 90 deg C in accordance with UL 83.
 4. Conductor Insulation Colors: Black (hot), white (neutral), and green (ground).
 5. Furnish on spools.

- B. Single, Twisted-Shielded, Instrumentation Cable 24 V and Less:
 - 1. Wire Size: Minimum 18 AWG.
 - 2. Conductors: Twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 - 3. Conductor Insulation: Nominal 15-mil thickness, constructed from flame-retardant PVC.
 - 4. Conductor Insulation Colors:
 - a. Twisted Pair: Black and white.
 - b. Twisted Triad: Black, red, and white.
 - 5. Shielding: 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 - 6. Outer Jacket Insulation: 300 V, 105 deg C rating, and Type PLTC cable.
 - 7. Furnish on spools.
- C. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
 - 1. Electronic and fiber-optic cables for control wiring are specified in Section 27 1500 "Communications Horizontal Cabling."
 - a. Plenum rated.
 - b. Unique color that is different from other cables used on Project.
- D. Serial Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
 - 1. Plenum rated.
 - 2. Shielded twisted pair.
 - 3. Comply with any third-party manufacturer requirements that are more stringent than the DDC system manufacturer's requirements.

2.29 PRESSURE INSTRUMENT SIGNAL AIR PIPING AND TUBING

- A. Products in this article are intended for use with the following:
 - 1. Main air and signal air to pneumatically controlled instruments, actuators, and other control devices and accessories.
 - 2. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
- B. Copper Tubing:
 - 1. Seamless phosphor deoxidized copper, drawn tempered, with chemical and physical properties in accordance with ASTM B75/B75M.
 - 2. Performance, dimensions, weight, and tolerance in accordance with ASTM B280.
 - 3. Diameter, as required by application, not less than nominal 1/4 inch.
 - 4. Wall thickness, as required by application, but not less than 0.030 inch.
 - 5. Copper Tubing Connectors and Fittings - Brass, Compression Type:
 - a. Single or double ferrule design creating a constant tension between fitting body and fitting nut for leak-free seal.
 - 6. Copper Tubing Connectors and Fittings - Copper, Solder-Joint Type:
 - a. Copper Solder-Joint Fittings: Cast, ASME B16.18 or wrought, ASME B16.22.
- C. Polyethylene Tubing: (For Pneumatic/Pressure Instrument Signal Air).
 - 1. Fire-resistant, black virgin polyethylene in accordance with ASTM D1248, Type 1, Class C, and Grade 5.
 - 2. Complying with stress crack test in accordance with ASTM D1693.

3. Diameter, as required by application, of not less than nominal 1/4 inch.
4. Polyethylene Tubing Connectors and Fittings - Brass, Barb Fittings:
 - a. Tapered and beaded hose barbs of push-on design; intended for low-pressure applications only.
5. Polyethylene Tubing Connectors and Fittings - Brass, Compression Type:
 - a. Specially designed for jointing polyethylene tubing to provide leak-free seal without twisting or weakening polyethylene tubing.

2.30 IDENTIFICATION

A. Instrument Air Pipe and Tubing:

1. Engraved tag bearing the following information:
 - a. Service (Example): "Instrument Air."
 - b. Pressure Range (Example): 0 to 30 psig.
2. Letter size minimum of 0.25 inch high.
3. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded blue with contrasting white center exposed by engraving through outer layer.
4. Include tag with brass grommet, chain, and S-hook.

B. Control Equipment, Instruments, and Control Devices:

1. Self-adhesive label bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Letter size as follows:
 - a. Servers: Minimum of 0.5 inch high.
 - b. DDC Controllers: Minimum of 0.5 inch high.
 - c. Gateways: Minimum of 0.5 inch high.
 - d. Repeaters: Minimum of 0.5 inch high.
 - e. Enclosures: Minimum of 0.5 inch high.
 - f. Electrical Power Devices: Minimum of 0.25 inch high.
 - g. UPS units: Minimum of 0.5 inch high.
 - h. Accessories: Minimum of 0.25 inch high.
 - i. Instruments: Minimum of 0.25 inch high.
 - j. Control Damper and Valve Actuators: Minimum of 0.25 inch high.
 - k. Engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers color-coded black with contrasting white center exposed by engraving through outer layer.
 - l. Fastened with drive pins.
 - m. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

C. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tag Size: Minimum 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

- D. Raceway and Boxes:
 - 1. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Paint cover plates on junction boxes and conduit same color as tape banding for conduits. After painting, label cover plate "HVAC Controls".
 - 3. For raceways housing pneumatic tubing, add phenolic tag labeled "HVAC Instrument Air Tubing."
 - 4. For raceways housing air signal tubing, add phenolic tag labeled "HVAC Air Signal Tubing."
- E. Equipment Warning Labels:
 - 1. Self-adhesive label with pressure-sensitive adhesive back and peel-off protective jacket.
 - 2. Lettering size at least 14-point type with white lettering on red background.
 - 3. Warning label to read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
 - 4. Lettering to be enclosed in a white line border. Edge of label is to extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.

3.2 TEMPERATURE INSTRUMENT APPLICATIONS

- A. Air Temperature Sensors:
 - 1. Duct, : 1000-ohm platinum RTD.
 - 2. Outdoor, : 1000-ohm platinum RTD.
 - 3. Space, : 1000-ohm platinum RTD.
- B. Air Temperature Transmitters:
 - 1. Duct, : Air temperature RTD transmitter.
 - 2. Outdoor, : Air temperature RTD transmitter.
 - 3. Space, : Air temperature RTD transmitter.
- C. Liquid and Steam Temperature Sensors:
 - 1. System, : Liquid and steam temperature sensor, high-end commercial grade.
- D. Liquid and Temperature Transmitters:
 - 1. System, : Liquid and steam temperature transmitter, commercial grade.

3.3 GENERAL

- A. All control system components shall be installed in locations as required to properly sense the controlled medium.

- B. BAS Installation shall be performed by professionals in a workmanlike manner and in compliance with the Contract Documents, Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and the following:
1. Complete BAS installation including all DDC Devices, Enclosures, wiring, equipment, control devices and sensors shall be installed in accordance with the manufacturers' recommended installation procedures and as specified.
 2. All flow stations (air and water) shall be installed according to the manufacturer's installation guidelines. This includes but is not limited to installation location, device orientation, flow direction, up/downstream distances from disturbances, and straight run requirements.
 3. All control devices are to be provided and installed with all required gaskets, seals, flanges, connection enclosures, thermal compounds, insulation, piping, fittings and valves as required for design operation, isolation, equalization, purging and calibration.
 4. Strap-on control devices shall not be permitted except as explicitly called out.
 5. All control devices mounted outdoors shall be protected by a weather-shield, integral outdoor enclosure, from ambient elements in such a manner as to not impede design functionality and/or sensing.
 6. BAS installation shall be such that it provides sufficient clearance for system maintenance by maintaining sufficient access for equipment, device and/or component service, calibration, removal, repair or replacement.
 7. BAS installation shall not interfere with required clearance for mechanical and/or electrical equipment maintenance.
 8. Penetrations through and mounting holes in the building exterior associated with the BAS installation shall be sealed and made water-tight.
 9. Dielectric isolation shall be provided where dissimilar metals are used in installation for connection and support.
- C. Installation, wiring and material shall be protected from damage or theft before, during, and after installation. Any damaged or stolen installation, wiring, or material shall be repaired or replaced.
- D. After completion of installation, calibrate and commission all components provided as part of the Control System and demonstrate proper sequence of operation in compliance with the specifications. BAS components not operating correctly shall be field corrected or replaced.

3.4 BAS APPLICATION SOFTWARE

- A. At time of acceptance all operating system, Third party and Control System Application software shall be at least the latest official release version available.
- B. Software programs are described to their general intent. It is recognized that Networked System manufacturer's software differ; however, the Application software provided shall incorporate the features described fully implemented and optimized to provide the sequences described, minimize energy consumption and prolong equipment life.
- C. When programming the system BACnet addressing rules will be strictly adhered to. All addressing strategies will have to be approved by Owner and Engineer of Record prior to configuring any LAN types.

- D. All analog and binary values shall be programmed with appropriate alarms.
- E. Except as specified otherwise, throttling ranges, proportional bands, and switching differentials shall be centered on the associated set point.
- F. All set points unless otherwise indicated are adjustable and shall be programmable for all control loops.
- G. Each control loop and/or interlock(s) for all mechanical system including terminal unit systems shall be programmed with a control loop specific graphical trend to trend all values associated with each specific control loop or system interlock.
- H. Where any sequence or occupancy schedule calls for more than one motorized unit to start simultaneously, the system start commands shall be staggered by 15-second (adj.) intervals to minimize inrush current.
- I. Scheduling shall be developed for each mechanical system. Final schedules shall be coordinated with the Owner and Engineer of Record prior to system commissioning.
- J. Optimal start/stop programs shall be applied to all regularly scheduled mechanical and electrical systems.
- K. At a minimum, trend log/historical data shall be implemented for every hardware point on the system. Additionally all software (virtual) points used as setpoints shall be trended. Point trends shall be grouped into logically interrelated points for individual mechanical and building systems. Initial set-up shall be to log values once every 5 minutes.
- L. B-AWS graphics shall conform to Smithsonian Institution graphic standards. All graphics shall be submitted to the SI and the Engineer of Record for review and approval prior to implementation. The Controls Contractor shall install all graphic displays for all systems and controlled devices in the FMCS database server located in the Herndon Data Center (HDC). Graphics shall display dynamic sensor readings in engineering units. Provide an overall riser diagram page, individual floor plan graphics for each floor, and system-level graphics. All space temperature and humidity readings available on the DDC system shall be interactively displayed on floor plan graphics.
- M. The Controls Contractor shall update the SI Siemens FMCS database with all set points, analog and digital input points, analog and digital output points, programs, application-specific controllers, schedules, alarm parameters, and user rights. The FMCS database server shall contain an exact copy of all DDC control sequences in the project.
- N. B-AWS Graphical User Interface (GUI) must be approved by the Owner and Engineer of Record and shall incorporate at a minimum the following:
 - 1. At a minimum, all physical hardware, sensors, control devices and set points shall be visible on a B-AWS in graphical form.
 - 2. All mechanical systems shall have a programmed real time color graphic for primary graphical user interface.
 - 3. Individual floor plan graphics will be programmed for each floor or area of the building. All space sensors shall be visible on floor plan graphics and system graphic.

3.5 B-AWS HARDWARE

- A. Provide as specified for each PC-Based B-AWS.
- B. Assemble server components in a configuration that allows easy operator access to all necessary components from one position.
- C. Provide sufficient permanent and removable storage drives for 25% free memory after provision for all operating system, Third party and Control System Application software, all fully configured point databases, storage/back-up of all B-BC, B-AAC and B-ASC application programming, all graphic files, all user-defined reports and a three year archive of all trend and historical data described in this specification.
- D. Provide sufficient RAM to meet system performance requirements.

3.6 BACNET PROTOCOL VERIFICATION SOFTWARE

- A. Use BACnet protocol verification software to confirm that all BACnet devices communicate correctly across all network segments and conform to the current BACnet standard (ANSI/ASHRAE 135). Verify that any integration with third-party systems or devices does not interfere with BACnet communication or cause degradation in network performance.

3.7 BUILDING CONTROLLER (B-BC)

- A. Provide as required to meet performance requirements of the system with a 10% increase in connected B-AAC and B-ASC on any individual network. Provide a dedicated B-BC for all project specific equipment requiring this controller type.
- B. Locate strategically such that B-BC locations are as equally distributed throughout the project as possible.
- C. All points used for a single mechanical system shall be connected to the same B-BC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
- D. Network Protocol Configuration: B-BCs shall be configured with BACnet MS/TP as the field-side (downstream) communication protocol for all connections to B-AACs, B-ASCs, and third-party devices. The B-BC BACnet/IP port shall be configured exclusively for upstream connection to the Owner's SI.edu network and the FMCS database server. The Controls Contractor shall confirm this dual-port configuration with the SI Systems Engineering Division – Controls Branch and Siemens Beltsville prior to submittal. Cross-connection of IP traffic to the field MS/TP network is strictly prohibited.
- E. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.

1. Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.

3.8 ADVANCED APPLICATION CONTROLLERS (B-AAC)

- A. Provide a dedicated B-AAC for each medium-sized mechanical system. Additionally, furnish one dedicated B-AAC for each Terminal Unit Mechanical Device on the project, including VAV and Fan Powered Terminal Units, Unit Heaters, and Individual Fans.
- B. All points used for a single mechanical system shall be connected to the same B-AAC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
- C. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.
 1. Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.
- D. VAV ATU and FP-VAV ATU Controllers
 1. Provide networked B-AAC for each VAV ATU and FP-VAV ATU consisting of a controller, damper actuator, and velocity transducer.
 2. The ATU shall be provided with multi-point averaging type flow sensor factory piped to the velocity transducer.

3.9 APPLICATION SPECIFIC CONTROLLERS (B-ASC)

- A. B-ASC controllers are only permitted when they can meet the full requirements of the project's sequences of operation. Provide a dedicated B-ASC for each Terminal Unit Mechanical Device on the project, including VAV and Fan Powered Terminal Units, Unit Heaters, and Individual Fans.
- B. All points used for a single Terminal Unit Mechanical Device shall be connected to a dedicated B-ASC. Points used for control loop reset based on outside air, or space/zone temperature, or extremely remote differential pressure sensors on slow acting control loops are exempt from this requirement.
- C. Provide spare additional I/O such that future use of spare capacity shall require providing only the field device, field wiring, point database definition and operational sequence programming changes as required. Additional point modules may be required to implement use of these spare points.
 1. Controllers shall be selected to provide a minimum of 15% spare I/O point capacity for each point type found at each location. If input points are not universal, 15% of each type is required. If outputs are not universal, 15% of each type is required. A minimum of one spare is required for each type of point used.

- D. VAV ATU and FP-VAV ATU Controllers
 - 1. Provide networked B-ASC for each VAV ATU and FP-VAV ATU consisting of a controller, damper actuator, and velocity transducer.
 - 2. The ATU shall be provided with multi-point averaging type flow sensor factory piped to the velocity transducer.

3.10 LOCAL SYSTEM NETWORK INTERFACE

- A. At a minimum the Portable B-AWS shall be able to connect to the BACnet Internetwork within each mechanical equipment space within the project.

3.11 CYBERSECURITY REQUIREMENTS

- A. General
 - 1. Implement cybersecurity measures to protect the BAS and connected networks from unauthorized access, data loss, and service interruption.
 - 2. Configure all devices, servers, and software to comply with these requirements during installation, setup, and commissioning.
 - 3. Coordinate with the Owner's IT department regarding network addressing, firewall configuration, and remote access policies.
- B. Network Configuration
 - 1. Segregate BAS network traffic from other building or enterprise networks using VLANs or firewalls approved by the Owner's IT department.
 - 2. Disable unused physical ports, communication services, and protocols.
 - 3. Restrict all inbound and outbound connections to those necessary for BAS operation.
 - 4. BACnet/IP traffic shall be limited to approved network segments and ports; block unnecessary broadcast traffic at the firewall.
 - 5. All web-based and remote access shall use secure protocols (HTTPS with TLS 1.2 or higher, SSH for administration, SFTP for file transfer).
 - 6. Remote or cloud connections shall be disabled unless explicitly approved by the Owner and secured via VPN or equivalent secure method.
- C. Device and Controller Configuration
 - 1. Remove or change all factory default usernames and passwords prior to commissioning.
 - 2. Configure strong passwords meeting Owner's minimum requirements (minimum 12 characters, complexity, expiration ≤ 90 days).
 - 3. Implement role-based access control (RBAC) and provide unique credentials for each user; enable multi-factor authentication (MFA) for administrative accounts where supported.
 - 4. Maintain logs of user access, configuration changes, and alarms; retain logs for at least 12 months.
 - 5. Install only necessary firmware, drivers, and software components; disable or remove all unnecessary applications and services.
 - 6. Verify that controller firmware and software are current and obtained from trusted sources.
- D. Server and Workstation Configuration
 - 1. Use currently supported operating systems and apply all critical security patches prior to turnover.

2. Configure automatic system updates where approved by the Owner.
3. Install and enable antivirus or endpoint protection software.
4. Configure local firewalls to permit only required BAS services and ports.
5. Provide the Owner with administrative credentials upon project completion.

E. Testing and Verification

1. Demonstrate that unsecured protocols (HTTP, Telnet, FTP) are disabled on all BAS devices and servers.
2. Demonstrate secure user authentication and access control.
3. Verify that BACnet/IP traffic is restricted to approved VLANs and ports.
4. Confirm that controllers and servers cannot be accessed from public networks without VPN or Owner-approved secure remote access.
5. Submit a final cybersecurity checklist documenting compliance with these requirements.

F. Documentation

1. Provide as-built network diagrams showing all BAS IP devices, addressing, and network segmentation.
2. Submit final list of user accounts, assigned roles, and access permissions.
3. Provide firmware and software version records for all controllers, servers, and gateways.
4. Deliver record of applied security updates and configuration changes at project closeout.

3.12 ENCLOSURES & SUB-PANELS

- A. All system components not designed for or required to be field installed shall be mounted in a control enclosure. Those components shall be sub panel mounted except components that are mounted on the panel face. Provide on/off power switch with over-current protection for control power sources in each local enclosure.
- B. All control enclosures shall be located so that visual observation and adjustment can be accomplished while standing flatfooted on the floor in a convenient location adjacent to the equipment served. Install all equipment in readily accessible location as defined by Chapter 1 Article 100 Part A of the NEC.
- C. Label all control system components.
- D. A copy of the As-built application engineering for the system served shall be laminated in clear plastic, shall be legible and suspended within enclosure.
- E. All B-BC shall be mounted in an enclosure.

3.13 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above the floor.
 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

- D. Install guards on thermostats in the following locations:
 - 1. Entrances.
 - 2. Public areas.
 - 3. Where indicated.
- E. Install automatic dampers according to Section 23 3300 "Air Duct Accessories."
- F. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- G. Install labels and nameplates to identify control components according to Section 23 0553 "Identification for HVAC Piping and Equipment."
- H. Install hydronic instrument wells, valves, and other accessories according to Section 23 2116 Hydronic Piping Specialties."
- I. Install steam and condensate instrument wells, valves, and other accessories according to Section 23 2216 Steam and Condensate Piping Specialties."
- J. Install refrigerant instrument wells, valves, and other accessories according to Section 23 2300 "Refrigerant Piping."
- K. Install duct volume-control dampers according to Section 23 3113 "Metal Ducts" and Section 23 3116 "Nonmetal Ducts."
- L. Install electronic and fiber-optic cables according to Section 27 1500 "Communications Horizontal Cabling."

3.14 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. General
 - 1. Provide all wiring required for a complete Control System.
 - 2. Control system wiring and cabling installed for this project shall be performed by professionals in a workmanlike manner and in accordance with the Contract Documents, Division 26 Project Electrical System Specifications, the National Electric Code (NEC), and any/all applicable local codes and/or Authorities Having Jurisdiction (AHJ) and shall include but may not be limited to the following:
 - a. All power wiring required not indicated on the electrical plans and specifications.
 - b. Power to all actuators and sensors.
 - c. Provide all wiring and cabling for network communications except for owner provided LANs/WANs.
 - d. All sensor and control device input and output wiring.
 - e. All interconnecting cabling between and amongst network devices, PCs printers, etc.
 - f. Interlock wiring between devices, variable frequency drives and between motor starters.
 - g. All other necessary wiring for fully complete and functional system as specified.
 - h. Install piping, wiring/cabling routed parallel to or at right angles with the structure, properly supported every six (6) feet at a minimum and installed in a workmanlike manner.

3. Maximum allowable voltage for control wiring shall be 120-volts.
 4. All wiring shall be installed as continuous links. Any required splices shall be made only within an approved junction box or other approved protective device with a maximum fill of 50%.
 - a. BACnet network cabling shall not be field spliced.
 5. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
 6. Terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- B. Power Wiring and Cabling
1. Obtain power and provide wiring for all enclosures and controls equipment, including branch circuit wiring from circuit breaker panels unless specifically shown on the Plans or Specifications to be provided under Division 26.
 2. All B-AWS equipment shall be served from isolated ground receptacles via UPS by dedicated branch circuits.
 3. All other enclosures, sensor and control devices shall be fed from separate circuits in the electrical distribution panels and shall not be served from the typical floor receptacle or lighting circuits.
- C. Network Wiring and Cabling
1. Network installation shall strictly adhere to the manufacturer's networking installation instructions and procedures.
 2. Network installation shall conform to standards for the LAN types and cabling types selected. Specific network rules inherent to the ANSI/ASHRAE Standard 135, BACnet shall be followed. Those include but are not limited to:
 - a. Only one path can exist from any BACnet device to another.
 - b. Each BACnet device connected to an internetwork LAN must have a unique device instance (0 - 4,194,303).
 - c. Each internetwork LAN must have a unique Network Number (1 - 65,545).
 3. Primary LAN Network wire and cable shall be run separately from all other wiring.
 4. Other LAN Network wire and cabling shall be installed separate from any wiring over thirty (30) volts.
 5. All communications shielding shall be grounded as per Networked System manufacturer's recommendations.
- D. Installation
1. Install raceways, boxes, and cabinets according to Section 26 0533 "Raceways and Boxes for Electrical Systems."
 2. Install building wire and cable according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 3. Install signal and communication cable according to Section 27 1500 "Communications Horizontal Cabling."
 - a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - b. Install exposed cable in raceway.
 - c. Install concealed cable in raceway.
 - d. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

- f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- 4. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- 5. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.15 INSTALLATION OF SENSORS

A. Temperature

- 1. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor readings.
- 2. Install and properly support all enclosures and sensing elements as much as possible in the center of duct cross section and in straight duct runs. In condensing environments use stainless steel flanges to support sensing elements.
- 3. Sensors mounted on air ducts having exterior insulation shall be provided with handy-box mounting with insulating material firmly fitted around handy-box.
- 4. Averaging type sensors: provide a minimum of 1 linear foot of sensor per 4 square feet of duct/coil area or equal to duct/coil width where installed, whichever is longer. Averaging sensing tubing shall serpentine vertically across airstream and be supported firmly by mechanical clips.
- 5. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 10 ft of sensing element for each 1 ft of sensing element for each 1 ft² of coil area.
- 6. Temperature sensors installed in piping or tanks shall be in separable thermowells. Sensors shall be inserted into thermowells with conductive paste. Assembly shall allow removal of sensor without loss of fluid.
- 7. At a minimum one outside air temperature sensor shall be installed. It shall be mounted outside on a northern exposure as high as serviceable on the building. The sensor shall be mounted within a ventilated enclosure to shield the sensor from the effects of the sun. The sensor location shall be selected such that it may not be affected by artificial and/or mechanical airstreams (i.e., building exhaust, building relief, etc.).
- 8. Terminal Unit Sensors shall be provided one per terminal unit device.
 - a. They shall be wall mounted in the space served 60" inches above finished floor and located as shown on drawings.
 - b. Provide a minimum of 16 feet of coiled temperature sensor control wiring for equipment with space sensor not located on the Drawings.
- 9. In all areas where terminal unit sensor locations are not known at the time of building startup, sensors shall be hung approximately 24 inches from the ceiling in the area of the controlled zone and connected. Control wiring shall be neatly coiled and attached to ceiling grid.
- 10. Zone temperature sensors shall not be located on perimeter walls. Where explicitly indicated on drawings to do so and/or in locations near exterior walls and/or subject to drafts sensors shall have insulated mounting bases to prevent false room temperature readings.
- 11. Where wall sensors are mounted in an area subject to damage provide suitable protective guard.
- 12. Where wall sensors are mounted in public spaces with adjustable set points provide suitable security guard.

- B. Wet Bulb
 - 1. For outside air mount same as outside air temperature sensor.
 - 2. For duct mounting execute same as duct mounted temperature sensor.
- C. Pressure
 - 1. Orient static pressure sensing taps faced directly down-stream in the airflow so as to eliminate velocity pressure effects. Locate pressure transducers within 10 feet of sensing point and use tubing sized such as to prevent signal phase lag.
 - a. Final location of static/differential pressure sensing taps shall be pursuant with Contract Documents and as indicated on drawings. Where not explicitly indicated on drawings, pressure sensing taps shall be located as follows:
 - 1) Duct static pressure control sensor tap shall be located 2/3 distance from the Air Handling Unit of the total duct length in a straight section of ductwork with a minimum of four (4) duct diameters in both directions.
 - 2) Positive static high-pressure safety cut-outs shall be located at Air Handling Unit immediately downstream of fan section.
 - 3) Mixed-Air static and/or differential sensor tap shall be located in mixing box section.
 - 4) Negative static pressure safety cut-outs shall be located immediately upstream of fan section.
 - 5) Filter differential pressure taps shall be installed on both filter inlet and outlet.
 - 6) Building Static Pressure. Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 7) The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 8) All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
 - b. Mount air differential pressure taps so that true differential is sensed.
 - 2. Water gauge taps shall include snubbers and isolation valves.
 - 3. Water differential pressure sensors shall be piped through a five-valve bypass assembly with snubbers.

3.16 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
 - 2. Test and adjust controls and safeties.
 - 3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
 - 4. Test each system for compliance with sequence of operation.

5. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

- D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.17 PROGRAMMING

- A. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.
- B. Point Naming. System point names shall be modular in design, allowing easy operator interface without the use of a written point index.
- C. Use device identification that is consistent with the established naming conventions at the place of work. Coordinate identification of equipment and systems supplied by other divisions to ensure that identical naming conventions are used.
- D. The BAS device network shall support up to a 32 character object name consisting only of ASCII printable characters. The convention to be used for all object names is as follows:
 1. Object name format shall be in the form of “xyz#-aaaaa-nnn-aaaaaaaaaaaa,” where “a” designates an alphanumeric character and “n” is a digit from 0 to 9. The underscore character is not allowed so that all names are compliant with domain naming conventions.
 2. The next three digits, “xyz#” followed by a dash “-”, designate a building identifier number. If fewer than three digits are used, the front of the building number must be padded with leading zeros.
 3. The next six alphanumeric characters, “aaaaa” followed by a dash “-”, designate the equipment or system name. No spaces are allowed in the equipment/system name; however, the name length may be shortened as required to no fewer than three alphanumeric characters.

4. The three digits “nnn” followed by a dash “-” designate the system number. If fewer than three digits are used, the front of the system number must be padded with leading zeros.
 5. The final thirteen alphanumeric characters, “aaaaaaaaaaaa,” designate the device or sensor connected to that system. No spaces are allowed in the device/sensor name; however, the name length may be shortened as required to no fewer than six alphanumeric characters.
- E. This naming convention applies to all objects provided by this contractor as well as to all objects that are mapped from the BACnet devices provided by others in the work.
- F. If the contractor’s panel does not support a maximum 32 character object name, map all objects to a BAS panel that supports this requirement.
- G. Software Programming
1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Embed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
 2. Text-based
 - a. Must provide actions for all possible situations
 - b. Must be modular and structured
 - c. Must be commented
 3. Graphic-based
 - a. Must provide actions for all possible situations
 - b. Must be documented
 4. Parameter-based
 - a. Must provide actions for all possible situations
 - b. Must be documented
 5. Submit sample programming of representative systems for approval by BAS designer.
- H. Operator Interface
1. Standard graphics—provide graphics for all mechanical systems and floor plans of the building. This includes each chilled-water system, hot-water system, chiller, boiler, air handler, and all terminal equipment. Point information on the graphic displays shall dynamically update. Show on each graphic all input and output points for the system. Also show relevant calculated points, such as set points.
 2. Submit sample graphic page layouts for approval by BAS designer.
 3. Show terminal equipment information on a graphic summary table. Provide dynamic information for each point shown.
 4. The contractor shall provide all the labor necessary to install, initialize, start up, and trouble- shoot all operator interface software and its functions as described in this section. This includes any operating system software, the operator interface database, and any third- party software installation and integration required for successful operation of the operator interface.
 5. All setpoints, timers, deadbands, PID gains, etc. listed in sequences shall be adjustable through the BAS interface by the user with appropriate access level whether indicated as adjustable in sequences or not. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

3.18 CALIBRATION, COMMISSIONING. DEMONSTRATION AND ACCEPTANCE

A. Commissioning, Calibrating and Adjusting:

1. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components," in the absence of specific requirements, and to supplement requirements indicated. Confirm in writing to the Owner and Architect the compliance with the field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Controls Components".
2. Pretest Checklist and Test Plan
 - a. Perform validation tests before requesting final review of system. Before beginning testing, first submit Pretest Checklist and Test Plan.
 - b. After approval by Owner or Architect of the Pretest Checklist and Test Plan, execute all tests and procedures indicated in plan.
 - c. After testing is complete, submit completed Pretest Checklist.
 - d. Pretest Checklist: Submit the following list with items checked off once verified:
 - 1) Detailed explanation for any items that are not completed or verified.
 - 2) Required mechanical installation work is successfully completed and HVAC equipment is working correctly.
 - 3) HVAC equipment motors operate below full-load amperage ratings.
 - 4) Required DDC system components, wiring, and accessories are installed.
 - 5) Installed DDC system architecture matches approved Drawings.
 - 6) Control electric power circuits operate at proper voltage and are free from faults.
 - 7) Required surge protection is installed.
 - 8) DDC system network communications function properly, including uploading and downloading programming changes.
 - 9) Using BACnet protocol analyzer, verify that communications are error free.
 - 10) Each controller's programming is backed up.
 - 11) Equipment, products, tubing, wiring cable, and conduits are properly labeled.
 - 12) All I/O points are programmed into controllers.
 - 13) Testing, adjusting, and balancing work affecting controls is complete.
 - 14) Dampers and actuators zero and span adjustments are set properly.
 - 15) Each control damper and actuator goes to failed position on loss of power and loss of signal.
 - 16) Valves and actuators zero and span adjustments are set properly.
 - 17) Each control valve and actuator goes to failed position on loss of power and loss of signal.
 - 18) Meter, sensor, and transmitter readings are accurate and calibrated.
 - 19) Control loops are tuned for smooth and stable operation.
 - 20) View trend data where applicable.
 - 21) Each controller works properly in standalone mode.
 - 22) Safety controls and devices function properly.
 - 23) Interfaces with fire-alarm system function properly.
 - 24) Electrical interlocks function properly.
 - 25) Operator workstations and other interfaces are delivered, all system and database software is installed, and graphics are created.
 - 26) Record Drawings are completed.
 - e. Test Plan:

- 1) Prepare and submit validation Test Plan including test procedures for performance validation tests.
- 2) Address all specified functions of DDC system and sequences of operation in Test Plan.
- 3) Explain detailed actions and expected results to demonstrate compliance with requirements indicated.
- 4) Explain method for simulating necessary conditions of operation used to demonstrate performance.
- 5) Include Test Checklist to be used to check and initial that each test has been successfully completed.
- 6) Submit Test Plan documentation twenty business days before start of tests.
3. Fully commission the entire BAS. All commissioning shall be fully documented and all documentation shall be submitted prior to Demonstration and Acceptance testing.
 - a. Commissioning shall include a point-to-point • check-out of all I/O points in the DDC system.
 - b. Verify that all Temperature Control Panels (TCP), BAS equipment, controllers, devices and sensors are installed and operational according to the specifications, submittals and manufacturer's installation and application instructions.
 - c. Calibrate all inputs by comparing the actual site condition with the B-AWS point display.
 - d. Verify all outputs from B-AWS command to observed response of controlled device.
 - e. Verify failure response and fail-safe conditions of all devices and safeties.
 - f. Each control program shall be fully commissioned and tested for complete design intent compliance and functionality.
 - 1) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
 - g. Verify overall network performance of BAS for complete design intent compliance and functionality with all devices on-line, communicating and fully-operational.
 - h. Subsystems not directly controlled by the BAS but associated with the ATC shall also be fully tested and commissioned as to design intent compliance and functionality.
 - i. Validation Test:
 - 1) Verify operating performance of each I/O point in DDC system.
 - a) Verify analog I/O points at operating value.
 - b) Make adjustments to out-of-tolerance I/O points.
 - c) Identify I/O points for future reference.
 - d) Simulate abnormal conditions to demonstrate proper function of safety devices.
 - e) Replace instruments and controllers that cannot maintain performance indicated after adjustments.
 - 2) Simulate conditions to demonstrate proper sequence of control.
 - 3) Readjust settings to design values and observe ability of DDC system to establish desired conditions.
 - 4) 24 hours after initial validation test, do as follows:
 - a) Re-check I/O points that required corrections during initial test.
 - b) Identify I/O points that still require additional correction and make corrections necessary to achieve desired results.
 - 5) 24 Hours after second validation test, do as follows:

- a) Re-check I/O points that required corrections during second test.
 - b) Continue validation testing until I/O point is normal on two consecutive tests.
- 6) Completely check out, calibrate, and test all connected hardware and software to ensure that DDC system performs according to requirements indicated.
- 7) After validation testing is complete, prepare and submit report indicating results of testing. For all I/O points that required correction, indicate how many validation re-tests it took to pass. Identify adjustments made for each test and indicate instruments that were replaced.
- j. DDC System Response Time Test:
 - 1) Simulate HLC.
 - a) Heavy load to be occurrence of 50 percent of total connected binary COV, one-half of which represents "alarm" condition, and 50 percent of total connected analog COV, one-half of which represents "alarm" condition, that are initiated simultaneously on a one-time basis.
 - 2) Initiate 10 successive occurrences of HLC and measure response time to typical alarms and status changes.
 - 3) Measure with timer having at least 0.1-second resolution and 0.01 percent accuracy.
 - 4) Purpose of test is to demonstrate DDC system, as follows:
 - a) Reaction to COV and alarm conditions during HLC.
 - b) Ability to update DDC system database during HLC.
 - 5) Passing test is contingent on the following:
 - a) Alarm reporting at printer beginning no more than two seconds after initiation (time zero) of HLC.
 - b) All alarms, both binary and analog, are reported and printed; none are lost.
 - c) Compliance with response times specified.
 - 6) Prepare and submit report documenting HLC tested and results of test including time stamp and print out of all alarms.
- k. DDC System Network Bandwidth Test:
 - 1) Test network bandwidth usage on all DDC system networks to demonstrate bandwidth usage under DDC system normal operating conditions and under simulated HLC.
 - 2) To pass, none of DDC system networks are to use more than 70 percent of available bandwidth under normal and HLC operation.
- 4. Calibrate instruments.
 - a. Make three-point calibration test for both linearity and accuracy for each analog instrument.
- 5. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
- 6. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
- 7. Flow:

- a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
 8. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 9. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
 10. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 11. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 12. Provide diagnostic and test instruments for calibration and adjustment of system.
 13. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
 - B. Adjust initial temperature and humidity set points.
 - C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.
 - D. Demonstration and Acceptance
 1. Demonstrate compliance of the BAS with the contract documents and operational functionality pursuant with the design Sequences of Operation. Using the documented calibration and commissioning test data the Owner and/or its representative shall select, at random, results to be demonstrated. At least 95% of the results demonstrated must perform as specified and documented on commissioning data sheets or the system must be re-calibrated and re-commissioned before being re-tested.
 2. When the Calibration, Commissioning, Demonstration and Acceptance process has been completed and approved by Owner, obtain signed letter from Owner indicating Acceptance within thirty (30) days of approval.
- 3.19 CONTROL VALVE INSTALLATION
- A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
 - B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball-type control valves shall be installed with the stem in the horizontal position.
 - C. Valves shall be installed in accordance with the manufacturer's recommendations.
 - D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.

- E. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 in. diameter with 0.25 in. high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.

3.20 CONTROL DAMPER INSTALLATION

- A. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
- B. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure 0.25 in. larger than damper dimensions and shall be square, straight, and level.
- C. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.125 in. of each other.
- D. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
- E. Install extended shaft or jackshaft according to manufacturer's instructions.
- F. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
- G. Provide a visible and accessible indication of damper position on the drive shaft end.
- H. Support ductwork in area of damper when required to prevent sagging due to damper weight.
- I. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.

3.21 ACTUATORS

- A. Mount and link control damper actuators according to manufacturer's instructions.
- B. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5 degrees open position, manually close the damper, and then tighten the linkage.
- C. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- D. Provide all mounting hardware and linkages for actuator installation.
- E. Electric/Electronic Actuators

1. Dampers. Actuators shall be direct-mounted on damper shaft or jackshaft unless shown as a linkage installation. For low-leakage dampers with seals, the actuator shall be mounted with a minimum 5 degrees available for tightening the damper seals. Actuators shall be mounted following manufacturer's recommendations.
2. Valves. Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

F. Pneumatic Actuators

1. Size pneumatic damper actuator to operate the related control damper(s) with sufficient reserve power to provide smooth modulating action or two-position action. Actuator also shall be sized for proper speed of response at the velocity and pressure conditions to which the control damper is subject.
2. Pneumatic damper actuators shall produce sufficient torque to close off against the maximum system pressures encountered. Size the pneumatic damper actuator to close off against the fan shutoff pressure, as a minimum.
3. Where two or more pneumatic damper actuators are installed for interrelated operation in unison, such as dampers used for mixing, provide the dampers with a positive pilot positioner. The positive pilot positioner shall be directly mounted to the pneumatic damper actuator and have pressure gages for supply input and output pressures.
4. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 20 ft² of damper.
5. Use line shafting or shaft couplings (jackshafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

3.22 CLEANING

- A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas

3.23 TRAINING

- A. Refer to Section 01 7900 "Demonstration and Training."
- B. Provide instruction on the adjustment, operation and maintenance of the BAS as installed including all hardware and software provided by a manufacturer-trained, competent application engineer and/or technician with sufficient experience in the installation, programming and operation of the BAS. Provide all training equipment and material.
- C. Training Schedule:
 1. Schedule training with Owner 20 business days before expected Substantial Completion.

2. Schedule training to provide Owner with at least 20 business days of notice in advance of training.
 3. Training to occur within normal business hours at mutually agreed on time. Unless otherwise agreed to, training to occur Monday through Friday, except on U.S. Federal holidays, with two morning sessions and two afternoon sessions. Each morning session and afternoon session to be split in half with 15 -minute break between sessions. Morning and afternoon sessions to be separated by 60 -minute lunch period. Training, including breaks and excluding lunch period, are not to exceed eight hours per day.
 4. Provide staggered training schedule as requested by Owner.
- D. Training Attendee List and Sign-in Sheet:
1. Request from Owner in advance of training a proposed attendee list with name, phone number, and email address.
 2. Provide preprinted sign-in sheet for each training session with proposed attendees listed and no fewer than six blank spaces to add additional attendees.
 3. Include preprinted sign-in sheet with training session number, date and time, instructor name, phone number, email address, and brief description of content to be covered during session. List attendees with columns for name, phone number, and email address and a column for attendee signature or initials.
 4. Circulate sign-in sheet at beginning of each session and solicit attendees to sign or initial in applicable location.
 5. At end of each training day, send Owner an email with attachment of scanned copy (PDF) of circulated sign-in sheet for each session..
- E. Attendee Training Manuals:
1. Provide each attendee with access to comprehensive training materials in both digital and optional printed formats.
 2. Digital Training Package:
 - a. A downloadable PDF binder containing all training content, organized with a hyperlinked table of contents and bookmarks for easy navigation.
 - b. Supplementary materials such as interactive presentations, video tutorials, and simulation exercises, accessible via a secure cloud-based platform or Learning Management System (LMS).
 - c. All files shall be compatible with standard devices and browsers, and accessible offline if needed.
 3. Printed Materials (Optional):
 - a. Upon request, provide a color-printed binder with tabbed dividers for each major topic area.
 - b. Include space for handwritten notes and printed copies of key visuals and diagrams.
- F. Organization of Training Sessions:
1. Organize training sessions into logical groupings of technical content and to reflect different levels of operators having access to system. Plan training sessions to accommodate the following three levels of operators:
 - a. Daily operators.
 - b. Advanced operators.
 - c. System managers and administrators.
 2. Plan and organize training sessions to group training content to protect DDC system security. Some attendees may be restricted to some training sessions to ensure DDC system security.

- G. Training Outline:
1. Submit training outline for Owner review at least ten business day before scheduling training.
 2. Include in outline a detailed agenda for each training day that is broken down into each of four training sessions that day, training objectives for each training session, and synopses for each lesson planned.
- H. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
 2. Provide training materials, projector, and other audiovisual equipment used in training.
 3. Provide as much of training located on-site as deemed feasible and practical by Owner.
 4. Include on-site training with regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
 5. Use operator workstation that is to be used with DDC system in the training. If operator workstations are unavailable, provide temporary workstation to convey training content.
- I. Training Content for Daily Operators:
1. Basic operation of system.
 2. Understanding DDC system architecture and configuration.
 3. Understanding each unique product type installed including performance and service requirements for each.
 4. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm, and each unique optimization routine.
 5. Operating operator workstations, printers, and other peripherals.
 6. Logging on and off system.
 7. Accessing graphics, reports, and alarms.
 8. Adjusting and changing set points and time schedules.
 9. Recognizing DDC system malfunctions.
 10. Understanding content of operation and maintenance manuals including control drawings.
 11. Understanding physical location and placement of DDC controllers and I/O hardware.
 12. Accessing data from DDC controllers.
 13. Operating portable operator workstations.
 14. Review of DDC testing results to establish basic understanding of DDC system operating performance and HVAC system limitations as of Substantial Completion.
 15. Running each specified report and log.
 16. Displaying and demonstrating each data entry to show Project-specific customizing capability. Demonstrating parameter changes.
 17. Stepping through graphics penetration tree, displaying all graphics, demonstrating dynamic updating, and direct access to graphics.
 18. Executing digital and analog commands in graphic mode.
 19. Demonstrating control loop precision and stability via trend logs of I/O for not less than 10 percent of I/O installed.
 20. Demonstrating DDC system performance through trend logs and command tracing.
 21. Demonstrating scan, update, and alarm responsiveness.
 22. Demonstrating spreadsheet and curve plot software, and its integration with database.
 23. Demonstrating on-line user guide, and help function and mail facility.

24. Demonstrating multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
25. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, normal-on, and failed conditions while observing individual equipment, dampers, and valves for correct position under each condition.
 - b. For HVAC equipment with factory-installed software, show that integration into DDC system is able to communicate with DDC controllers or gateways, as applicable.
 - c. Using graphed trends, show that sequence of operation is executed in correct manner, and HVAC systems operate properly through complete sequence of operation including seasonal change, occupied and unoccupied modes, warm-up and cool-down cycles, and other modes of operation indicated.
 - d. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - e. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.
 - f. Each control loop responds to set-point adjustment and stabilizes within time period indicated.
 - g. Sharing of previously graphed trends of all control loops to demonstrate that each control loop is stable and set points are being maintained.
- J. Training Content for Advanced Operators:
 1. Making and changing workstation graphics.
 2. Creating, deleting, and modifying alarms including annunciation and routing.
 3. Creating, deleting, and modifying point trend logs including graphing and printing on an ad-hoc basis and operator-defined time intervals.
 4. Creating, deleting, and modifying reports.
 5. Creating, deleting, and modifying points.
 6. Creating, deleting, and modifying programming including ability to edit control programs offline.
 7. Creating, deleting, and modifying system graphics and other types of displays.
 8. Adding DDC controllers and other network communication devices such as gateways and routers.
 9. Adding operator workstations.
 10. Performing DDC system checkout and diagnostic procedures.
 11. Performing DDC controllers operation and maintenance procedures.
 12. Performing operator workstation operation and maintenance procedures.
 13. Configuring DDC system hardware including controllers, workstations, communication devices, and I/O points.
 14. Maintaining, calibrating, troubleshooting, diagnosing, and repairing hardware.
 15. Adjusting, calibrating, and replacing DDC system components.
- K. Training Content for System Managers and Administrators:
 1. DDC system software maintenance and backups.
 2. Uploading, downloading, and offline archiving of all DDC system software and databases.
 3. Interface with Project-specific, third-party operator software.
 4. Understanding password and security procedures.

5. Adding new operators and making modifications to existing operators.
 6. Operator password assignments and modification.
 7. Operator authority assignment and modification.
 8. Workstation data segregation and modification.
- L. Video of Training Sessions:
1. Provide digital video and audio recording of each training session. Create separate recording file for each session.
 2. Stamp each recording file with training session number, session name, and date.
 3. Provide Owner with two copies of digital files on cloud and flash drives for later reference and for use in future training.
 4. Owner retains right to make additional copies for intended training purposes without having to pay royalties.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 1123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Joining materials.
 - 4. Manual gas shutoff valves.
 - 5. Pressure regulators.
 - 6. Dielectric fittings.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. An example includes rooftop locations.
- C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Piping specialties.
 - 2. Corrugated, stainless steel tubing with associated components.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 4. Pressure regulators. Indicate pressure ratings and capacities.
 - 5. Dielectric fittings.
- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawing Scale: 1/4 inch per foot (1:50).
 - 2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Welding certificates.
- C. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- D. Field quality-control reports.
- E. Qualification Statements: For professional engineer.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For motorized gas valves pressure regulators service meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with the ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping in accordance with requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide purging and startup of natural-gas supply in accordance with requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for piping identification for natural-gas piping. Comply with requirements in Section 22 0553 "Identification of Plumbing Piping and Equipment."

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each product type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Comply with the International Fuel Gas Code.
- B. Minimum Operating-Pressure Ratings:
 1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
- C. Natural-Gas System Pressure within Buildings:
 1. Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa), but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel, Schedule 40, Type E or S, Grade B.
 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 2. Wrought-Steel Welding Fittings: ASTM A234/A234M for butt welding and socket welding.
 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
 5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

- a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- 6. Mechanical Couplings:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Baker Hughes Company.
 - 2) Smith-Blair, a Xylem brand.
 - 3) Insert manufacturer's name.
 - b. Steel flanges and tube with epoxy finish.
 - c. NBR seals.
 - d. Steel bolts, washers, and nuts.
 - e. Coupling is to be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - f. Steel body couplings installed underground on plastic pipe are to be factory equipped with anode.

2.4 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
 - 1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - 2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - 4. Corrugated, stainless steel tubing with polymer coating.
 - 5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
 - 6. End Fittings: Zinc-coated steel.
 - 7. Threaded Ends: Comply with ASME B1.20.1.
 - 8. Maximum Length: 72 inches (1830 mm).
- B. Quick-Disconnect Devices: Comply with ANSI Z21.41.
 - 1. Copper-alloy convenience outlet and matching plug connector.
 - 2. Seals: Nitrile.
 - 3. Hand operated with automatic shutoff when disconnected.
 - 4. For indoor or outdoor applications.
 - 5. Adjustable, retractable restraining cable.
- C. Y-Pattern Strainers:
 - 1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
 - 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - 3. Strainer Screen: 40 60-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
 - 4. CWP Rating: 125 psig (862 kPa).
- D. Basket Strainers:
 - 1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 - 2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - 3. Strainer Screen: 40 60-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
 - 4. CWP Rating: 125 psig (862 kPa).

- E. T-Pattern Strainers:
 - 1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
 - 2. End Connections: Grooved ends.
 - 3. Strainer Screen: 40 -mesh startup strainer, and perforated stainless steel basket with 57 percent free area.
 - 4. CWP Rating: 750 psig (5170 kPa).
- F. Weatherproof Vent Cap:
 - 1. Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.5 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.6 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig (862 kPa).
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 - 5. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 - 6. Service Mark: Valves NPS 1-1/4 to NPS 2 (DN 32 to DN 50) having initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
 - 1. CWP Rating: 125 psig (862 kPa).
 - 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - 3. Tamperproof Feature: Locking feature for valves indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 - 4. Service Mark: Initials "WOG" permanently marked on valve body.
- C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. BrassCraft Manufacturing Co.; a Masco company.
 - d. Perfection Corporation.
 - e. R.W. Lyall; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - f. Insert manufacturer's name.
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated brass.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Separate packnut with adjustable-stem packing threaded ends.
 7. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. BrassCraft Manufacturing Co.; a Masco company.
 - d. Perfection Corporation.
 - e. R.W. Lyall; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - f. Insert manufacturer's name.
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. BrassCraft Manufacturing Co.; a Masco company.
 - d. Perfection Corporation.

- e. R.W. Lyall; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - f. Insert manufacturer's name.
 2. Body: Bronze, complying with ASTM B584.
 3. Ball: Chrome-plated bronze.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 8. CWP Rating: 600 psig (4140 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- F. Bronze Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Lee Brass Company.
 - c. Insert manufacturer's name.
 2. Body: Bronze, complying with ASTM B584.
 3. Plug: Bronze.
 4. Ends: Threaded, socket, or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 5. Operator: Square head or lug type with tamperproof feature where indicated.
 6. Pressure Class: 125 psig (862 kPa).
 7. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- G. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Mueller Co. LLC; Mueller Water Products, Inc.
 - c. XOMOX; Crane ChemPharma & Energy.
 - d. Insert manufacturer's name.
 2. Body: Cast iron, complying with ASTM A126, Class B.
 3. Plug: Bronze or nickel-plated cast iron.
 4. Seat: Coated with thermoplastic.
 5. Stem Seal: Compatible with natural gas.
 6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
 7. Operator: Square head or lug type with tamperproof feature where indicated.
 8. Pressure Class: 125 psig (862 kPa).
 9. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

H. Cast-Iron, Lubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Flowserve Corporation.
 - c. Homestead Valve: a division of Olson Technologies, Inc.
 - d. Milliken Valve Company; a Mueller brand.
 - e. Mueller Co. LLC; Mueller Water Products, Inc.
 - f. R & M Energy Systems; Robbins & Myers.
 - g. Insert manufacturer's name.
2. Body: Cast iron, complying with ASTM A126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged as indicated in "Underground, Manual Gas Shutoff Valve Schedule" and "Aboveground, Manual Gas Shutoff Valve Schedule" articles.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig (862 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller are to be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.7 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80A.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Actaris: a brand of ITT Controls.
 - b. American Meter Company.
 - c. Dormont; A Watts Water Technologies Company.
 - d. Eclipse Innovative Thermal Technologies.
 - e. Fischer; Emerson Electric Co., Automation Solutions.
 - f. Itron Inc.
 - g. Maxitrol Company.
 - h. Richards Industrials.
 - i. Schneider Electric USA, Inc.
 - j. Insert manufacturer's name.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR; resistant to gas impurities, abrasion, and deformation at the valve port.

6. Orifice: Aluminum; interchangeable.
7. Seal Plug: UV-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to regulator.
9. Pressure regulator is to maintain discharge pressure setting downstream and is to not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 5 psig (34.5 kPa).

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Canadian Meter Company, LLC; a Honeywell Company.
 - b. Dormont; A Watts Water Technologies Company.
 - c. Eaton.
 - d. Harper Wyman Co.
 - e. Maxitrol Company.
 - f. SCP, Inc.
 - g. Insert manufacturer's name.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: NBR.
6. Seal Plug: UV-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig (6.9 kPa).

2.8 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. GF Piping Systems: Georg Fischer LLC.
 - d. HART Industrial Unions, LLC.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. WATTS; A Watts Water Technologies Company.
 - h. Wilkins.
 - i. Zurn Industries, LLC.
 - j. Insert manufacturer's name.

2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) 150 psig (1035 kPa) 250 psig (1725 kPa) Insert pressure.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
 - C. Dielectric Flanges:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Company.
 - b. GF Piping Systems: Georg Fischer LLC.
 - c. Matco-Norca.
 - d. WATTS; A Watts Water Technologies Company.
 - e. Wilkins.
 - f. Insert manufacturer's name.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C) 150 psig (1035 kPa) 175 psig (1200 kPa) 300 psig (2070 kPa) Insert pressure.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 - D. Dielectric-Flange Insulating Kits:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, LLC.
 - b. CALPICO, Inc.
 - c. GF Piping Systems: Georg Fischer LLC.
 - d. GPT; a division of EnPRO Industries.
 - e. Insert manufacturer's name.
 2. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.
- 2.9 LABELING AND IDENTIFYING
- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description and rated pressure of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.
 - B. Label and identify gas piping and pressure outside a multitenant building by tenant.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping in accordance with the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with the International Fuel Gas Code requirements for preventing accidental ignition.

3.3 INSTALLATION OF OUTDOOR PIPING

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches (900 mm) below finished grade, install it in containment conduit.
- C. Install underground, PE, natural-gas piping in accordance with ASTM D2774.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Copper Tubing with Protective Coating:
 - 1. Apply joint cover kits over tubing to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- F. Install fittings for changes in direction and branch connections.
- G. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Section 23 0500 "Common Work Results for HVAC."

3.4 INSTALLATION OF INDOOR PIPING

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.

- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Do not install piping in concealed locations unless sleeved with the sleeve open at both ends.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Where installing piping above accessible ceilings, allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access. Do not locate valves within return air plenums.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
 - 2. Install sediment trap on both sides of regulators for gas reduction to 2 psig (13.8 kPa) with valve and cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 2. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 3. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 4. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Section 23 0500 "Common Work Results for HVAC."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 0500 "Common Work Results for HVAC."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 0500 "Common Work Results for HVAC."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 0500 "Common Work Results for HVAC."
- 3.5 INSTALLATION OF VALVES
- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless steel tubing, aluminum, or copper connector.
- B. Install underground valves with valve boxes.

- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.
- F. Do not install valves in return-air plenums.

3.6 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, and then use wrench. Do not overtighten.
- H. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join in accordance with ASTM D2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for corrugated stainless steel tubing, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within 12 inches (300 mm) of each fitting.
- F. Support vertical runs of steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- G. Support vertical runs of corrugated stainless steel tubing to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.8 PIPING CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas-appliance equipment grounding conductor of the circuit powering the appliance in accordance with NFPA 70.
- C. Where installing piping adjacent to appliances, allow space for service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.

3.9 LABELING AND IDENTIFICATION

- A. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.10 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Use 3000 psig (20.7 MPa), 28-day, compressive-strength concrete and reinforcement as specified in Section 03 3000 "Cast-in-Place Concrete."

3.11 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 1. Test, inspect, and purge natural gas in accordance with the International Fuel Gas Code and authorities having jurisdiction.
 2. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- B. Prepare test and inspection reports.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.13 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping is to be the following:
 1. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground natural-gas piping is to be one of the following:
 1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with wrought-steel fittings and welded joints.

3.14 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG (3.45 kPa)

- A. Aboveground, branch piping NPS 1 (DN 25) and smaller is to be one of the following:
 1. Corrugated stainless steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
 2. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping is to be one of the following:
 1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with wrought-steel fittings and welded joints.

3.15 ABOVEGROUND, MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
 2. Two-piece, regular-port, bronze ball valves with bronze trim.
 3. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter are to be one of the following:
1. Two-piece, regular-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.
 3. Cast-iron, nonlubricated plug valve.
- C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
 2. Two-piece, regular-port, bronze ball valves with bronze trim.
 3. Bronze plug valve.
- D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger are to be one of the following:
1. Two-piece, regular-port, bronze ball valves with bronze trim.
 2. Bronze plug valve.
 3. Cast-iron, nonlubricated plug valve.
- E. Valves in branch piping for single appliance are to be one of the following:
1. One-piece, bronze ball valve with bronze trim.
 2. Two-piece, regular-port, bronze ball valves with bronze trim.
 3. Bronze plug valve.

END OF SECTION

SECTION 23 2113 - HYDRONIC PIPING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Copper tube and fittings.
 - 2. Steel pipe and fittings.
 - 3. Stainless steel pipe and fittings.
 - 4. Piping joining materials.
 - 5. Transition fittings.
 - 6. Dielectric fittings.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Pipe and tube.
 - 2. Fittings.
 - 3. Joining materials.
 - 4. Transition fittings.
- B. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 3. Environmental Product Declaration: For each product.
 - 4. Health Product Declaration: For each product.
 - 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
 - 6. Environmental Product Declaration: For each product.
 - 7. Environmental Product Declaration: For each product.
 - 8. Third-Party Certifications: For each product.
 - 9. Third-Party Certified Life Cycle Assessment: For each product.
- C. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
 - 1. Provide delegated-design submittal for the following:
 - a. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
 - b. Locations of pipe anchors, alignment guides, and expansion joints and loops.
 - c. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
 - d. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Qualification Data: For Installer.
- C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- B. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9 for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.5 WARRANTY

- A. PP-R and PP-RCT Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R and PP-RCT pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
 - 1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system was tested and passed manufacturer's pressure/leak test and any other manufacturer requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design hydronic piping.
 - 1. Material properties indicated in this Section shall be considered as minimum properties.
- B. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
 - 1. Hot-Water Heating Piping: 250 psig (1724 kPa) at 200 deg F (93 deg C).
 - 2. Chilled-Water Piping: 250 psig (1724 kPa) at 73 deg F (22 deg C).
 - 3. Energy Recovery Glycol Water Piping: 150 psig (1034 kPa) at 150 deg F (66 deg C).
 - 4. Makeup-Water Piping: 150 psig (1034 kPa) at 150 deg F (66 deg C).
 - 5. Condensate-Drain Piping: 180 deg F (82 deg C).
 - 6. Air-Vent Piping: 200 deg F (93 deg C).
 - 7. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B88, Type L (ASTM B88M, Type B).
- B. DWV Copper Tube: ASTM B306, Type DWV.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- F. Cast-Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- G. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M black steel with plain ends; welded and seamless, Grade B, and schedule number as indicated in Part 3, "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3, "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3, "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3, "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A234/A234M; wall thickness to match adjoining pipe.
- G. Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.

2.4 STAINLESS STEEL PIPE AND FITTINGS

- A. Stainless Steel Pipe, Plain Ends: ASTM A312/A312M plain ends, seamless; stainless steel of types and schedules as indicated in Part 3 "Piping Applications" Article.
- B. Stainless Steel Piping, Pressure-Seal-Joint Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 - b. Smith-Cooper International.
 - c. Victaulic Company.
 - d. Viega LLC.
 - 2. Obtain stainless steel piping pressure-seal-joint fittings from single manufacturer.
 - 3. Material: ASTM A312/A312M, Type 316, stainless steel, Schedule 10.
 - 4. Fittings: Type O-Rings and Pipe Stop: EPDM.
 - 5. Tools: Manufacturer's special tool.
 - 6. Minimum 300 psig (2070 kPa) working-pressure rating at 230 deg F (110 deg C).

2.5 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B32, lead-free alloys.
- D. Flux: ASTM B813, water flushable.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. GF Piping Systems: Georg Fischer LLC.

- d. HART Industrial Unions, LLC.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. WATTS.
 - h. Wilkins.
 - i. Zurn Industries, LLC.
 2. Source Limitations: Obtain dielectric unions from single manufacturer.
 3. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 250 psig (1725 kPa).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous. Solder joints are not to be used on pipe sizes greater than NPS 4 (DN 100).
- C. Dielectric Flanges:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. GF Piping Systems: Georg Fischer LLC.
 - b. WATTS.
 - c. Wilkins.
 - d. Zurn Industries, LLC.
 2. Source Limitations: Obtain dielectric flanges from single manufacturer.
 3. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 300 psig (2070 kPa).
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC.
 - b. Calpico, Inc.
 - c. GF Piping Systems: Georg Fischer LLC.
 - d. GPT; a division of EnPRO Industries.
 2. Source Limitations: Obtain dielectric-flange insulating kits from single manufacturer.
 3. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International/Smith-Cooper International; Tailwind Capital, LLC.
 - b. Elster Perfection; a Honeywell Company .
 - c. GPT; a division of EnPRO Industries.
 - d. Matco-Norca.
 - e. Precision Plumbing Products.

- f. Sioux Chief Manufacturing Company, Inc.
 - g. Victaulic Company.
2. Source Limitations: Obtain dielectric nipples from single manufacturer.
3. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F1545.
 - c. Pressure Rating: Minimum 300 psig (2070 kPa) at 225 deg F (107 deg C).
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-Water Heating Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
 2. Schedule 40, Grade B, steel pipe; Class 250, cast-iron fittings; and threaded joints.
 3. Schedule 5, Type 304, stainless steel pipe; Type 316, stainless steel pressure-seal fittings; and pressure-seal joints.
- B. Hot-Water Heating Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
 1. Schedule 40, Grade B, steel pipe; Class 250 cast-iron fittings; welded joints, cast-iron flanges, flange-fittings, and flanged joints.
- C. Chilled-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to be Any of the Following:
 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
 2. Schedule 40, Grade B steel pipe; Class 250, cast-iron fittings; and threaded joints.
 3. Schedule 5, Type 304, stainless steel pipe; Type 316, stainless steel pressure-seal fittings; and pressure-seal joints.
- D. Chilled-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
 1. Schedule 40, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
- E. Glycol Cooling-Water Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
 2. Schedule 40, steel pipe; Class 250, cast-iron fittings; and threaded joints.
 3. Schedule 5, Type 304, stainless steel pipe; Type 316, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
- F. Glycol Cooling-Water Piping, Aboveground, NPS 2-1/2 (DN 65) and Larger, to Be Any of the Following:
 1. Schedule 40, Grade B, steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

- G. Makeup-Water Piping Installed Aboveground to Be Any of the Following:
 - 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed joints.
 - 2. Schedule 5, Type 304, stainless steel pipe; Type 316, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
- H. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:
 - 1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered brazed pressure-seal joints.
 - 2. Schedule 5, Type 304, stainless steel pipe; Type 316, stainless steel pressure-seal couplings and fittings; and pressure-seal joints.
- I. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.
 - 2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.
- J. Pressure-Relief-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed, with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.

- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
 - 1. Section 23 0523.11 "Globe Valves for HVAC Piping."
 - 2. Section 23 0523.12 "Ball Valves for HVAC Piping."
 - 3. Section 23 0523.13 "Butterfly Valves for HVAC Piping."
 - 4. Section 23 0523.14 "Check Valves for HVAC Piping."
 - 5. Section 23 0523.15 "Gate Valves for HVAC Piping."
- Q. Install air vents and pressure-relief valves in accordance with Section 23 2116 "Hydronic Piping Specialties."
- R. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.
- T. Install shutoff valve immediately upstream of each dielectric fitting.
- U. Comply with requirements in Section 23 0516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- V. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for identifying piping.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 23 0517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 23 0517 "Sleeves and Sleeve Seals for HVAC Piping."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 23 0518 "Escutcheons for HVAC Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 - 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join in accordance with ASTM D2846/D2846M Appendix.
 - 3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe, and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings in accordance with ASTM D2855.
 - 4. PVC Nonpressure Piping: Join in accordance with ASTM D2855.
- I. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.
- J. Mechanically Formed Tee Fittings: Use manufacturer-recommended tools, procedure, and brazed joints.
- K. Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.4 INSTALLATION OF DIELECTRIC FITTINGS

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flange kits.
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- B. Install hangers for copper tubing and steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- C. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- F. Support vertical runs of copper tubing and steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- G. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. 1/2 inch piping is not allowed. Provide end reducers if needed.
- B. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.
- C. Install control valves in accessible locations close to connected equipment.
- D. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- E. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 23 0519 "Meters and Gauges for HVAC Piping."

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 23 0553 "Identification for HVAC Piping and Equipment."

3.8 SYSTEM STARTUP

- A. Perform the following before operating the system:
 1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

3.9 FIELD QUALITY CONTROL

- A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:
 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 2116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hydronic specialty valves.
 - 2. Air vents.
 - 3. Expansion tanks and fittings.
 - 4. Air/dirt separators and purgers.
 - 5. Strainers.
 - 6. Flexible connectors.
 - 7. Coil Connection Kits.
- B. Related Requirements:
 - 1. Section 23 0500 "Common Work Results for HVAC" for expansion fittings and loops.
 - 2. Section 23 0523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for general-duty valves common to most piping systems.
 - 3. Section 23 0923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product:
 - 1. Include construction details and material descriptions for hydronic piping specialties.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.
- B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

A. Bronze, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Armstrong Fluid Technology.
 - d. Bell & Gossett; a Xylem brand.
 - e. Flamco; a division of AALBERTS Ind.
 - f. Gerand Engineering Co.
 - g. Griswold Controls, LLC.
 - h. Hays Fluid Controls.
 - i. HCI; Hydronics Components Inc.
 - j. IMI Flow Design, Inc.
 - k. Jenkins Valves; a Crane Co. brand.
 - l. Jomar Valve.
 - m. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - n. NIBCO INC.
 - o. NuTech Hydronic Specialty Products.
 - p. Oventrop Corporation.
 - q. Red-White Valve Corp.
 - r. Taco Comfort Solutions.
 - s. Tour & Andersson; available through Victaulic Company.
 - t. Tunstall Corporation.
 - u. Victaulic Company.
 - v. WATTS; A Watts Water Technologies Company.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig (860 kPa).
10. Maximum Operating Temperature: 250 deg F (121 deg C).

B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Armstrong Fluid Technology.
 - d. ASC Engineered Solutions.
 - e. Bell & Gossett; a Xylem brand.
 - f. Flamco; a division of AALBERTS Ind.
 - g. Gerand Engineering Co.

- h. Griswold Controls, LLC.
 - i. Hammond Valve.
 - j. Hays Fluid Controls.
 - k. HCI; Hydronics Components Inc.
 - l. IMI Flow Design, Inc.
 - m. IMI Hydronic Engineering Inc.
 - n. Jenkins Valves; a Crane Co. brand.
 - o. Jomar Valve.
 - p. KITZ Corporation.
 - q. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - r. NIBCO INC.
 - s. NuTech Hydronic Specialty Products.
 - t. Oventrop Corporation.
 - u. Red-White Valve Corp.
 - v. Tour & Andersson; available through Victaulic Company.
 - w. Tunstall Corporation.
 - x. Victaulic Company.
 - y. WATTS; A Watts Water Technologies Company.
 - 2. Body: Cast-iron or steel body, ball, butterfly, plug, or globe pattern with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Disc: Glass- and carbon-filled PTFE.
 - 6. Seat: PTFE.
 - 7. End Connections: Flanged or grooved.
 - 8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 - 9. Handle Style: Lever, with memory stop to retain set position.
 - 10. CWP Rating: Minimum 125 psig (860 kPa).
 - 11. Maximum Operating Temperature: 250 deg F (121 deg C).
- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Caleffi North America.
 - d. Jenkins Valves; a Crane Co. brand.
 - e. Keckley Company.
 - f. NIBCO INC.
 - g. Oventrop Corporation.
 - h. Spence Engineering Company, Inc.
 - i. Taco Comfort Solutions.
 - j. Victaulic Company.
 - k. WATTS; A Watts Water Technologies Company.
 - l. Zurn Industries, LLC.
 - 2. Body: Bronze or brass.
 - 3. Disc: Brass.
 - 4. Seat: Brass.
 - 5. Stem Seals: EPDM O-rings.
 - 6. Diaphragm: EPDM.
 - 7. Low inlet-pressure check valve.

8. Inlet Strainer: , removable without system shutdown.
 9. Valve Seat and Stem: Noncorrosive.
 10. Valve Size and Capacity: As indicated on Drawings.
 11. Operating Pressure: Factory set and field adjustable.
- D. Diaphragm-Operated Pressure-Relief Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Flamco; a division of AALBERTS Ind.
 - d. Keckley Company.
 - e. WATTS; A Watts Water Technologies Company.
 - f. Zurn Industries, LLC.
 2. Body: Bronze or brass.
 3. Disc: Steel.
 4. Seat: Steel.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPDM.
 7. Valve Seat and Stem: Noncorrosive.
 8. Valve Size, Capacity, and Operating Pressure: Comply with ASME BPVC, Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- E. Automatic Flow-Control Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil; an ASC Engineered Solution.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. Bell & Gossett; a Xylem brand.
 - d. Caleffi North America.
 - e. Flamco; a division of AALBERTS Ind.
 - f. Flowcon Americas LLC.
 - g. Griswold Controls, LLC.
 - h. Hays Fluid Controls.
 - i. HCI; Hydronics Components Inc.
 - j. IMI Flow Design, Inc.
 - k. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - l. NIBCO INC.
 - m. NuTech Hydronic Specialty Products.
 - n. Oventrop Corporation.
 - o. Red-White Valve Corp.
 - p. Spence Engineering Company, Inc.
 - q. Tunstall Corporation.
 - r. Victaulic Company.
 - s. WATTS; A Watts Water Technologies Company.
 2. Body: Brass or ferrous metal.
 3. Combination Assemblies: Include bronze or brass-alloy ball valve.
 4. Identification Tag: Marked with zone identification, valve number, and flow rate.
 5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.

6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: 300 psig (2070 kPa).
8. Maximum Operating Temperature: 200 deg F (93 deg C).

2.2 AIR VENTS

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Caleffi North America.
 - d. Flamco; a division of AALBERTS Ind.
 - e. HCI; Hydronics Components Inc.
 - f. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - g. NuTech Hydronic Specialty Products.
 - h. Taco Comfort Solutions.
 - i. WATTS; A Watts Water Technologies Company.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 225 deg F (107 deg C).

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Caleffi North America.
 - d. Flamco; a division of AALBERTS Ind.
 - e. Flo Fab Inc.
 - f. Metraflex Company (The).
 - g. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - h. NuTech Hydronic Specialty Products.
 - i. Oventrop Corporation.
 - j. Spirotherm, Inc.
 - k. Taco Comfort Solutions.
 - l. WATTS; A Watts Water Technologies Company.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/4 (DN 8).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 240 deg F (116 deg C).

2.3 EXPANSION TANKS AND FITTINGS

- a. AMTROL, Inc.
- b. AMTROL, Inc.

B. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Armstrong Fluid Technology.
 - c. Bell & Gossett; a Xylem brand.
 - d. Flo Fab Inc.
 - e. Taco Comfort Solutions.
 - f. WATTS; A Watts Water Technologies Company.
2. Tank: Welded steel, rated for 125 psig (860 kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. Field-replaceable bladder.
4. Sight glass.
5. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
 - a. AMTROL, Inc.
 - b. Flamco; a division of AALBERTS Ind.

2.4 AIR/DIRT SEPARATORS AND PURGERS

A. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Armstrong Fluid Technology.
 - c. Bell & Gossett; a Xylem brand.
 - d. Caleffi North America.
 - e. Flamco; a division of AALBERTS Ind.
 - f. Flo Fab Inc.
 - g. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - h. Spirotherm, Inc.
 - i. Taco Comfort Solutions.
2. Tank: Fabricated steel tank; ASME constructed and stamped for 125 psig (862 kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: Stainless steel Insert material.
4. Air Vent: Threaded to top of separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to bottom of separator.
7. Size: Match system flow capacity.
 - a. AMTROL, Inc.
 - b. Flamco; a division of AALBERTS Ind.
 - c. Spirotherm, Inc.
 - d. AMTROL, Inc.
 - e. Flamco; a division of AALBERTS Ind.

- f. Spirotherm, Inc.
- g. Spirotherm, Inc.

2.5 STRAINERS

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. ASC Engineered Solutions.
 - c. Caleffi North America.
 - d. Flexicraft Industries.
 - e. Flo Fab Inc.
 - f. FNW; Ferguson Enterprises, Inc.
 - g. Griswold Controls, LLC.
 - h. Hays Fluid Controls.
 - i. Keckley Company.
 - j. Metraflex Company (The).
 - k. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - l. Titan Flow Control, Inc.
 - m. Victaulic Company.
 - n. WATTS; A Watts Water Technologies Company.
 - o. Zurn Industries, LLC.
2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
3. Minimum size = NPS 0.75"
4. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
5. Strainer Screen: Stainless steel, Typically 20 -mesh strainer, or perforated stainless steel basket. See drawings for 20-mesh strainer, or perforated stainless steel basket, where called out.
6. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Flo Fab Inc.
 - c. Keckley Company.
 - d. Metraflex Company (The).
 - e. Titan Flow Control, Inc.
 - f. WATTS; A Watts Water Technologies Company.
 - g. Zurn Industries, LLC.
2. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
3. Minimum size = NPS 0.75"
4. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
5. Strainer Screen: 40 -mesh startup strainer and perforated stainless steel basket with 50 percent free area.
6. CWP Rating: 125 psig (860 kPa).

2.6 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Flo Fab Inc.
 - c. Metraflex Company (The).
2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
3. End Connections: Threaded or flanged to match equipment connected.
4. Performance: Capable of 3/4-inch (20-mm) misalignment.
5. CWP Rating: 150 psig (1035 kPa).
6. Maximum Operating Temperature: 250 deg F (121 deg C).

2.7 COIL CONNECTION KITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Nexus
2. Nibco
3. Griswold
4. Bell and Gossett

B. General Performance Criteria:

1. Coil Connection Kits shall be designed for a minimum 600 PSIG WOG working pressure for sizes 0.75" through 2½" and up to 325 degrees F.
2. Each Coil Connection Kit shall include a combination automatic flow control valve, isolation valve, and union with (2) pressure & temperature test plugs; combination y-strainer, isolation valve, blow down/ drain valve, and union with (1) pressure and temperature test plug; accessory port union with (1) manual air vent and (1) pressure and temperature test plug.
3. Extended handles shall not break the vapor barrier when operated.
4. Optional extended pressure and temperature test plugs, manual air vents and handles shall be available.
5. Minimum size of kit shall be NPS 3/4". Provide end reducers for final connection, as needed, if equipment connection terminals are smaller than NPS 3/4".

C. Automatic Flow Control Valves:

1. The flow cartridge's non-clogging single orifice design shall include no metal-to-metal contact, no segmented ports, no rolling diaphragm, and incorporate a tapered profile flow nozzle and metering disk controlled by a pressure compensating spring.
2. The flow cartridge shall be a single assembly, constructed with stainless steel moving parts and be accessible without removing the valve from the piping. Flow cartridges constructed with composite or rubber materials are not acceptable.
3. The flow cartridge shall be factory flow tested and calibrated to maintain accuracy of ±5%; the accuracy shall be maintained over a standard operating range of 2 - 45 PSIG. Cartridges that prevent flow above the maximum operating range are not acceptable.

4. The flow cartridge shall be clearly inscribed with the designed manufactured flow rate. Cartridges that are not marked with the manufacture designed flow rate or use a coding system are not acceptable.
5. Manufacturer shall provide a full 100% cartridge exchange for up to one (1) year from date of delivery at no charge. Exchange shall be provided for flow rate changes within same valve body.
6. The flow cartridge and valve shall carry a 5-year product warranty.
7. Valves 1½" and smaller shall be a forged brass Y-pattern body and valves 2" - 2½" shall be a cast brassy-pattern body with integrated ball valve, (2) pressure/temperature test ports, a tag indicating the model, flow rate and PSIG range, blowout proof stem with dual FKM o-ring seals, interchangeable union end with FKM o-ring seal, hard chrome plated solid ball with Teflon seats, and rated at 600 PSI WOG, 325 degrees F.

D. Y Strainers:

1. Minimum size = 0.75"
2. Y type strainers 0.75" through 2½" shall be a combination Y Strainer and Ball Valve with integrated Union.
3. Valves shall be a forged brass construction for sizes ½" through 1½" and cast brass for sizes 2" - 2½" with the following features:
 - a. A minimum of 600 PSI WOG, 325 degrees F.
 - b. Interchangeable union end with FKM o-ring seal.
 - c. Multiple ¼" tapped ports for test plugs, vents or other accessories.
 - d. Blowout proof stem with dual FKM o-rings.
 - e. Hard chrome plated ball with Teflon seats.
 - f. A 304 stainless steel filter screen accessible without affecting the valve piping.
 - g. A port in the filter cap for a blow down/drain valve.
 - h. Valve shall carry a 5-year product warranty.

E. Unions

1. Unions ½" through 2½" shall be a combination ported type. Unions shall be a forged brass construction with the following features:
 - a. A minimum of 600 PSI WOG, 325 degrees F.
 - b. Interchangeable union end with Viton o-ring seal.
 - c. Multiple ¼" tapped ports for test plugs, vents or other accessories.
 - d. Union shall carry a 5-year product warranty.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine all piping specialties for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Examine threads on all devices for form and cleanliness.
- C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

- D. Do not attempt to repair defective piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

- A. Install calibrated-orifice balancing valve at each branch connection to return main.
- B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.
- C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.
- C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- E. Install diaphragm- or bladder-type expansion tanks on the floor.
- F. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.
- G. Coil connection kit size shall match the pipe size shown on floor plans. Furnish end fittings as needed if the equipment connectors do not match the kit size.

END OF SECTION

SECTION 23 2123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.

1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump.
 - 1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
 - 2. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1. American-Marsh Pumps.
 - 2. Armstrong Fluid Technology.
 - 3. Aurora Pump; Pentair Ltd.
 - 4. Crane Pumps & Systems.
 - 5. Flowserve Corporation.
 - 6. Grundfos Pumps Corporation.
 - 7. ITT Corporation.
 - 8. Mepco, LLC.
 - 9. PACO Pumps; Grundfos Pumps Corporation, USA.
 - 10. Patterson Pump Company; a Gorman-Rupp company.
 - 11. Peerless Pump Company.
 - 12. Taco Comfort Solutions.
 - 13. Thrush Co. Inc.
 - 14. Insert manufacturer's name.
- B. Source Limitations: Obtain pumps from single source from single manufacturer.
- C. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- D. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange union-end connections.
 - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - 3. Pump Shaft Sleeve: Bronze Type 304 stainless steel.
 - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and NBR EPDM FKM Insert material rubber bellows and gasket. Include water slinger on shaft between motor and seal.

5. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.
- E. Shaft Coupling: Rigid, axially-split spacer coupling to allow service of pump seal without disturbing pump or motor.
- F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
 1. Enclosure : **[Totally enclosed, fan cooled]** <Insert enclosure type>.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. **[Single]** **[Variable]**-speed motor.
 6. Provide integral pump motor variable-speed controller.
 7. **<Insert unique motor characteristics>**.

2.3 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser:
 1. Angle pattern.
 2. 175-psig (1204-kPa) 300-psig (2060-kPa) pressure rating, cast ductile-iron body and end cap, pump-inlet fitting.
 3. Bronze 16-mesh wire startup and bronze Type 304 stainless steel permanent strainers with 3/16-inch (4.8-mm) perforations and 51 percent open area).
 4. Bronze Carbon steel Type 304 stainless steel straightening vanes.
 5. Drain plug.
 6. Factory-fabricated support.
- B. Triple-Duty Valve:
 1. Angle or straight pattern.
 2. 175-psig (1204-kPa) 300-psig (2060-kPa) pressure rating, **[cast]** **[ductile]**-iron body, pump-discharge fitting.
 3. Valve with multi-turn stem and memory stop to allow valve to be returned to its original position after shutoff.
 4. Brass valve disc with EPDM rubber seat.
 5. Type 304 stainless steel valve stem.
 6. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
 7. Brass gauge ports with integral check valve and orifice for flow measurement.

2.4 INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

- A. Where specified or scheduled, provide pumps with an integral pump motor speed controller.
 1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
 2. Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: Modbus RTU BACnetTM MS/TP Metasys N2.
 3. Commissioning and pump set up access to pump controls via the following:
 - a. A web interface (data exchange).

- b. A user interface located on the face of speed controller to adjust modes and mode values.
 - c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.
 - 4. Provide electronics with "Auto" as factory default but slope of the proportional curve will automatically match the required system curve, constant pressure control ($\Delta p/c$), variable differential pressure control ($\Delta p/v$), constant curve duty (uncontrolled pump), and rpm regulation. RPM (speed) regulation can be accomplished by the following:
 - a. Manual (via user interface or HTML).
 - b. Remote via 0 to 10 V dc.
 - c. Data protocol communications with the BMS.
 - 5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
 - 6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.
 - 7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
 - 8. Pump capable of being monitored continuously via integrated Internet link.
 - 9. Integrated pump controller system to have the following features:
 - a. Controller software shall be capable of sensorless control in variable-volume systems without need for pump-mounted (internal/external) or remotely mounted differential pressure sensor.
 - b. Integrated Pump Controller Sensorless Control: Operates under Quadratic Pressure Control (QPC) to ensure that head reduction with reducing flow conforms to quadratic control curve.
 - c. Controller:
 - 1) Minimum head of 40 percent of design duty head.
 - 2) User-adjustable control mode settings and minimum/maximum head set points using built-in programming interface.
 - d. Controller Integrated Control Software:
 - 1) Capable of controlling pump performance for non-overloading power at every point of operation.
 - 2) Capable of maintaining flow rate data.
- 2.5 ELECTRONICALLY COMMUTATED MOTOR (ECM)
- A. Provide pumps so they are specified or scheduled with ECM.
- 1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
 - 2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
 - 3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
 - 4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.
 - 5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
 - 6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with [HI 1.4] [and] [HI 2.4].
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.
- E. Equipment Mounting:
 - 1. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- F. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and [elastomeric hangers] [spring hangers] [spring hangers with vertical-limit stop] of size required to support weight of in-line pumps.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."
 - 2. Comply with requirements for hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

- A. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.

- B. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 23 2213 "Steam and Condensate Heating Piping" and Section 23 2216 "Steam and Condensate Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install **[check, shutoff, and throttling valves]** **[check valve and throttling valve with memory stop]** **[triple-duty valve]** on discharge side of pumps.
- F. Install **[Y-type strainer]** **[suction diffuser]** and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.
- I. Install check valve on each condensate pump unit discharge unless unit has a factory-installed check valve.

3.5 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 26 0523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform] [Perform]** startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Check piping connections for tightness.
 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 6. Start motor.
 7. Open discharge valve slowly.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION

SECTION 23 2513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water treatment for closed-loop hydronic systems.
2. Manual chemical-feed equipment.
3. Automatic chemical-feed equipment.
4. Chemicals.
5. Inhibited ethylene glycol and propylene glycol.

B. Related Requirements:

1. Section 23 2533 "HVAC Makeup-Water Filtration Equipment" for water treatment of water softeners, RO equipment, and filtration equipment.
2. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 DEFINITIONS

A. RO: Reverse osmosis.

B. TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.

C. TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. Chemical solution tanks.
6. Injection pumps.
7. Chemical-treatment test equipment.
8. Chemical material safety data sheets.
9. Inhibited ethylene glycol.
10. Inhibited propylene glycol.

B. Shop Drawings: Pretreatment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to hydronic systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- B. Field quality-control reports.
- C. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- D. Water Analysis: Illustrate water quality available at Project site.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anderson Chemical Company.
 - 2. Aqua-Chem, Inc.
 - 3. Barclay Water Management, Inc.
 - 4. Boland Trane Services.
 - 5. Cascade Water Services, Inc.
 - 6. Earthwise Environmental Inc.
 - 7. H-O-H Water Technology, Inc.
 - 8. Metro Group, Inc. (The).
 - 9. Nalco; an Ecolab company.
 - 10. Sonitec-Vortisand Inc.
 - 11. Suez Water Technologies (Formerly GE Water).
 - 12. Watcon, Inc.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems, as indicated in this Specification. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including glycol heating and glycol cooling shall have the following water qualities:
 - 1. pH: Maintain a value within **<Insert range>**.
 - 2. Alkalinity: Maintain a value within **<Insert range>** mg/L as CaCO₃.
 - 3. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to **<Insert number>** mils per year. Maintain soluble iron concentrations at or below **<Insert value>** mg/L.
 - 4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to **<Insert number>** mils per year. Maintain soluble copper concentrations at or below **<Insert value>** mg/L.
 - 5. Scale Control: Provide softened water for initial fill and makeup. **[Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.]**
 - 6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
 - 7. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of **<Insert number>** organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of **<Insert number>** organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of **<Insert number>** organisms/mL.
 - 8. **<Insert other applicable requirements>**.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Provide steel feeders with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Provide quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - 1. Capacity: 2 gal. (7.6 L) 5 gal. (19 L) Insert value.
 - 2. Minimum Working Pressure: 125 psig (860 kPa) 175 psig (1210 kPa) Insert value.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT

- A. Water Meter, Piston Type, Threaded:
 - 1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
 - 2. Body: Bronze.
 - 3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
 - 4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 - 5. Registration: Gallons (Liters) or cubic feet (cubic meters).
 - 6. End Connections: Threaded.
 - 7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**

8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 23 0923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
 9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**
- B. Water Meter, Turbine Type, Threaded:
1. AWWA C701, turbine-type, totalization meter.
 2. Body: Bronze.
 3. Minimum Working-Pressure Rating: 100 psig (690 kPa).
 4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 5. Registration: Gallons (Liters) or cubic feet (cubic meters).
 6. End Connections: Threaded.
 7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
 8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 23 0923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
 9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**
- C. Water Meter, Turbine Type, Flanged:
1. AWWA C701, turbine-type, totalization meter.
 2. Body: **[Bronze] [Epoxy-coated cast iron].**
 3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
 4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
 5. Registration: Gallons (Liters) or cubic feet (cubic meters).
 6. End Connections: Flanged.
 7. **[Controls: Flow-control switch with normally open contacts, rated for maximum 10 A, 250-V ac, that will momentarily close at adjustable increments of total flow.]**
 8. **[Electronic or digital interface for flow rate indication at central workstation compatible with DDC system, as described in Section 23 0923 "Direct Digital Control (DDC) System for HVAC." Low-voltage signal must be capable of transmitting 1000 feet (305 m).]**
 9. **[Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.]**
- D. Chemical Solution Tanks:
1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
 2. Molded cover with recess for mounting pump.
 3. Capacity: 30 gal. (114 L) 50 gal. (189 L) 120 gal. (454 L) Insert value.
- E. Chemical Solution Injection Pumps:
1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.

2. Adjustable flow rate.
 3. Metal and thermoplastic construction.
 4. Built-in relief valve.
 5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 23 0500 "Common Work Results for HVAC."
 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A269/A269M, Type 304 stainless steel for steam boiler injection assemblies.
- G. Injection Assembly:
1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
 2. Ball Valve: Three Two-piece, stainless steel; selected to fit quill.
 3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
 4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.5 CHEMICAL-TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounted cabinet for testing pH, corrosion inhibitors, alkalinity, hardness, and other properties recommended by manufacturer.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
1. Two -station rack for closed-loop systems.

2.6 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer, compatible with piping system components and connected equipment, and able to attain water quality specified in "Performance Requirements" Article.

2.7 INHIBITED ETHYLENE GLYCOL AND PROPYLENE GLYCOL

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. Dynalene.
 2. Fremont Industries.
 3. Houghton Chemical Corp.
 4. The Dow Chemical Company.
 5. Insert manufacturer's name.
- B. Inhibited Propylene Glycol:

1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon steel, brass, copper, stainless steel, and cast-iron piping and fittings.
2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. pH value shall be maintained between <Insert range>, with reserve alkalinity greater than <Insert number> mL.
4. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
5. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to [minus 20 deg F (minus 29 deg C)] <Insert number>. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
6. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drain.
- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. Comply with requirements in Section 23 0548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including glycol heating, and glycol cooling, and equip with the following:
 1. Install bypass feeder in a bypass circuit around circulating pumps unless indicated otherwise on Drawings.
 2. Install water meter in makeup-water supply.
 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 5. Install a swing check on the inlet after the isolation valve.

- G. Install automatic fluid make-up equipment for glycol water system, and include the following:
 - 1. Chemical solution tanks.
 - 2. Chemical solution injection pumps.
 - 3. Water meter in makeup supply to system.
 - 4. Pressure switch to operate injection pump as necessary to maintain glycol system pressure.

3.3 PIPING CONNECTIONS

- A. Piping installation requirement are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 23 2113 "Hydronic Piping."
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 23 0523 "General-Duty Valves for HVAC Piping."
- E. Comply with requirements in Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.

3.4 ELECTRICAL CONNECTIONS

- A. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.

5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. At six -week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis, advising Owner of changes necessary to adhere to "Performance Requirements" Article.
- F. Comply with ASTM D3370 and with the following standards:
1. Silica: ASTM D859.
 2. Acidity and Alkalinity: ASTM D1067.
 3. Iron: ASTM D1068.
 4. Water Hardness: ASTM D1126.

3.6 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

END OF SECTION

SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 1. Single-wall rectangular ducts and fittings.
 2. Single-wall round ducts and fittings.
 3. Sheet metal materials.
 4. Sealants and gaskets.
 5. Hangers and supports.
- B. Related Requirements:
 1. Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 2. Section 23 3116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
 3. Section 23 3119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 4. Section 23 3300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 1. Liners and adhesives.
 2. Sealants and gaskets.
- B. Sustainable Design Submittals:
 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 3. Product Data: For adhesives, indicating VOC content.
 4. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 5. Product Data: For sealants, indicating VOC content.
 6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
 7. Laboratory Test Reports: For antimicrobial coatings, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings:
 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 2. Factory- and shop-fabricated ducts and fittings.
 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 4. Elevation of top and bottom of ducts.
 5. Dimensions of all duct runs from building grid lines.
 6. Fittings.

7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

D. Delegated Design Submittals:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: A single set of plans or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Welding certificates.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and with performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports are to withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
- C. Wind Performance: Ducts are to withstand the effects of wind determined in accordance with to ASCE/SEI 7. See Section 23 0548 "Vibration and Seismic Controls for HVAC."

- D. Airstream Surfaces: Surfaces in contact with airstream comply with requirements in ASHRAE 62.1.
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- F. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- G. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts located entirely inside the building of galvanized sheet steel unless otherwise indicated.
 - a. If a length or a segment of duct run is outside the building (example, outside air intake for boilers), the paragraph below on "For ducts exposed to weather" shall apply to the entire run of the duct, including branches located indoors.
 - 2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Utilize duct joining system for all ducts 6" and greater.
 - 2. For ducts with longest side less than 36 inches (914 mm), select joint types in accordance with Figure 2-1.
 - 3. For ducts with longest side 36 inches (914 mm) or greater, use factory prefabricated slide-on transverse flanged duct connection systems.
 - 4. Manufacturers: Subject to compliance with requirements, provide products by one of the following -
 - a. Ductmate Industries Inc.
 - b. Nexus PDQ, a Division of Shilco Holdings, Inc.
 - c. Ward Industries, Inc. a Division of Hart and Cooley, Inc.
 - 5. Pre-fabricated, manufactured flanged connectors shall be provided with:
 - a. Steel materials matching the duct construction.
 - b. Roll-formed flanges. Add-on flanged duct connectors may be used with Architect's or Engineer's approval.
 - c. Gage and shape to be in accordance with manufacturer's guidelines.
 - d. Manufacturer's duct construction and reinforcement guidelines with independent leakage testing, deflection and seismic performance.
 - e. Provide with manufacturer's installation criteria for fastener and cleat spacing.
 - f. Minimum independent test leakage rate at 10 inch water gage positive or negative.
 - 6. Where specified for specific applications, all joints are to be welded.

- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." All longitudinal seams are to be Pittsburgh lock seams unless otherwise specified for specific application.
 - 1. Where specified for specific applications, all joints are to be welded.
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 - 3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elgen Manufacturing.
 - b. GSI; a DMI Company.
 - c. Linx Industries (formerly Lindab).
 - d. McGill AirFlow LLC.
 - e. MKT Metal Manufacturing.
 - f. Nordfab Ducting.
 - g. SEMCO, LLC; part of FlaktGroup.
 - h. Set Duct Manufacturing.
 - i. Sheet Metal Connectors, Inc.
 - j. Spiral Manufacturing Co., Inc.
 - k. Stamped Fittings Inc.
- B. Source Limitations: Obtain single-wall round ducts and fittings from single manufacturer.
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- D. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- E. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.
- F. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials are to be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
 - 3. Any ductwork that is field painted shall be galvanized A60.
- C. Carbon-Steel Sheets: Comply with ASTM A1008/A1008M, with oiled, matte finish for exposed ducts.
- D. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish is to be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply on all exhaust ductwork.
 - 2. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating is to be applied to the exterior surface.
 - 3. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 4. Coating containing the antimicrobial compound is to have a hardness of 2H, minimum, when tested in accordance with ASTM D3363.
 - 5. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.

6. Shop-Applied Coating Color: Black or White.
 7. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- G. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- H. Tie Rods: Galvanized steel, 1/4-inch- (6-mm-) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch- (10-mm-) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets are to be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 3 inches (76 mm) 4 inches (102 mm) 6 inches (152 mm).
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 10. Sealant shall have a VOC content of 420 g/L or less.
 11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." and LEED v4.
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10 inch wg (2500 Pa), positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Solvent-Based Joint and Seam Sealant:
1. Application Method: Brush on.

2. Base: Synthetic rubber resin.
 3. Solvent: Toluene and heptane.
 4. Solids Content: Minimum 60 percent.
 5. Shore A Hardness: Minimum 60.
 6. Water resistant.
 7. Mold and mildew resistant.
 8. Sealant shall have a VOC content of 420 g/L or less.
 9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." and LEED v4.
 10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
 11. Service: Indoor or outdoor.
 12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- E. Flanged Joint Sealant: Comply with ASTM C920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. Sealant shall have a VOC content of 420 g/L or less.
 7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." and LEED v4.
- F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- G. Round Duct Joint O-Ring Seals:
1. Seal is to provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and is to be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.
- 2.6 HANGERS AND SUPPORTS
- A. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.

- E. Steel Cables for Stainless Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless Steel Ducts: Stainless steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

- J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 23 3300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
- N. Branch Connections: Use lateral or conical branch connections.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCTWORK EXPOSED TO WEATHER

- A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.
- B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
- C. Single Wall:
 - 1. Ductwork is to be Type 316 stainless steel.
 - 2. Ductwork is to be galvanized steel.

- a. If duct outer surface is uninsulated, protect outer surface with fully customized and suitable paint color approved by Architect. Paint materials and application requirements are specified in Section 09 9113 "Exterior Painting."
- 3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 23 0713 "Duct Insulation."

3.4 DUCT SEALING

- A. Seal Class A; no exceptions.
- B. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 23 0548 "Vibration and Seismic Controls for HVAC."
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 DUCTWORK CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 23 3300 "Air Duct Accessories."

- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 09 9113 "Exterior Painting" and Section 09 9123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - a. Ducts with a Pressure Class 3-inch wg and Higher: Test 100 percent for each designated pressure class.
 - b. Ducts with a Pressure Class Lower than 3-inch wg: Test representative duct sections, selected by Architect or Engineer from sections installed, totaling no less than 50 percent of total installed duct area.
 - c. Test pressure shall be equal to construction class.
 - d. Leakage from ductwork shall be no more than 2%.
 - e. Total allowable system leakage shall be no more than 5%.
 2. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 3. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 4. Test for leaks before applying external insulation.
 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 6. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
 1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness in accordance with "Description of Method 3 - NADCA Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media is to not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. For cleaning of existing ductwork, see Section 23 0130.52 "Existing HVAC Air Distribution System Cleaning."
- C. Use duct cleaning methodology as indicated in NADCA ACR.
- D. Use service openings for entry and inspection.
 - 1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 23 3300 "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- E. Particulate Collection and Odor Control:
 - 1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - 2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
- F. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.
- G. Mechanical Cleaning Methodology:
 - 1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - 2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - 3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - 4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

5. Clean coils and coil drain pans in accordance with NADCA ACR. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.10 STARTUP

- A. Air Balance: Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 1. Fabricate all ducts to achieve SMACNA pressure class, seal class, and leakage class as indicated below.
- B. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel or carbon steel coated with zinc-chromate primer.
 2. Stainless Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Galvanized.
 3. Aluminum Ducts: Aluminum.
- C. Elbow Configuration:
 1. Rectangular Duct - Requirements for Different Velocities: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm (5 m/s) or Lower:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows.," where radius elbows do not fit.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - a) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio may be acceptable for occasional instances approved by Engineer.
 - 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows.," where radius elbows of 1.0 radius-to-diameter ratio do not fit.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows.," where radius elbows do not fit.

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 (305) Inches (mm) and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 (356) Inches (mm) and Larger in Diameter: Standing seam.
- D. Branch Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in.
 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION

SECTION 23 3300 - AIR DUCT ACCESSORIES**PART 1 - GENERAL****1.1 SUMMARY****A. Section Includes:**

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Turning vanes.
11. Remote damper operators.
12. Duct-mounted access doors.
13. Duct access panel assemblies.
14. Flexible connectors.
15. Duct accessory hardware.

B. Related Requirements:

1. Section 23 3346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 23 3723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Section 28 4621.11 "Addressable Fire-Alarm Systems" for duct-mounted fire and smoke detectors.
4. Section 28 4621.13 "Conventional Fire-Alarm Systems" for duct-mounted fire and smoke detectors.

1.2 ACTION SUBMITTALS**A. Product Data:** For each type of product.

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Detail duct accessories' fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor-damper installations, including sleeves; and duct-mounted access doors and remote damper operators.

- e. Duct security bars.
- f. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.
- B. Source quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a Mestek Architectural Group company.
 - 2. Cesco Products; a division of MESTEK, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Lloyd Industries, Inc.
 - 5. Nailor Industries Inc.
 - 6. NCA Manufacturing, Inc.
 - 7. Pottorff.
 - 8. Ruskin Company.
 - 9. Safe Air - Dowco Products.
 - 10. United Enertech.
 - 11. Vent Products Co., Inc.
- B. Description: Gravity balanced.

- C. Performance:
1. Maximum Air Velocity: 3000 fpm (15 m/s).
 2. Maximum System Pressure: 6 inches wg (1.5 kPa).
 3. AMCA Certification: Test and rate in accordance with AMCA 511.
 4. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
- D. Construction:
1. Frame:
 - a. Hat shaped.
 - b. 18-gauge- (1.3-mm-) thick stainless steel, with welded or mechanically attached corners and mounting flange.
 2. Blades:
 - a. Multiple single-piece blades.
 - b. Center pivoted, maximum 6-inch (150-mm) width, 26-gauge (0.48-mm) Type 304 stainless steel with sealed edges.
 3. Blade Action: Parallel.
- E. Blade Seals: Extruded vinyl, mechanically locked.
- F. Blade Axles:
1. Material: Aluminum.
 2. Diameter: 0.20 inch (5 mm).
- G. Tie Bars and Brackets: Aluminum.
- H. Return Spring: Adjustable tension.
- I. Bearings: Steel ball.
- J. Damper Actuator - Electric:
1. Electric - 24 V ac.
 2. UL 873 plenum rated.
 3. Fully modulating with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.
 4. Clockwise or counterclockwise drive rotation as required for application.
 5. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C).
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
 6. Environmental Enclosure: NEMA 2.
 7. Actuator to be factory mounted and provided with a single-point wiring connection.
- K. Controllers, Electrical Devices, and Wiring:
1. Comply with requirements for electrical devices and connections specified in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
 2. Electrical Connection: 24 V, 60 Hz.

L. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Chain pulls.
4. Screen Mounting:
 - a. Front mounted in sleeve.
 - 1) Sleeve Thickness: 20 gauge (1.0 mm) minimum.
 - 2) Sleeve Length: 6 inches (150 mm) minimum.
5. Screen Material: Aluminum.
6. Screen Type: Bird Insect.
7. 90-degree stops.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance; a division of MESTEK, Inc.
 - b. Aire Technologies.
 - c. American Warming and Ventilating; a Mestek Architectural Group company.
 - d. Arrow United Industries.
 - e. Cesco Products; a division of MESTEK, Inc.
 - f. Greenheck Fan Corporation.
 - g. Lloyd Industries, Inc.
 - h. McGill AirFlow LLC.
 - i. Nailor Industries Inc.
 - j. Pottorff.
 - k. Ruskin Company.
 - l. Safe Air - Dowco Products.
 - m. United Enertech.
 - n. Vent Products Co., Inc.
2. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
3. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
4. Frames:
 - a. Hat-shaped, 18-gauge- (1.3-mm-) thick stainless steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Stainless steel; 16 gauge (1.6 mm) thick.
6. Blade Axles: Stainless steel.
7. Bearings:
 - a. Oil-impregnated stainless steel sleeve.

- b. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
- 8. Tie Bars and Brackets: Galvanized steel.
- 9. Locking device to hold damper blades in a fixed position without vibration.
- B. Jackshaft:
 - 1. Size: 1-inch (25-mm) diameter.
 - 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- C. Damper Hardware:
 - 1. Zinc-plated, die-cast core with dial and handle, made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
 - 2. Include center hole to suit damper operating-rod size.
 - 3. Include elevated platform for insulated duct mounting.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance; a division of MESTEK, Inc.
 - 2. Aire Technologies.
 - 3. Arrow United Industries.
 - 4. Cesco Products; a division of MESTEK, Inc.
 - 5. CL WARD & Family Inc.
 - 6. Greenheck Fan Corporation.
 - 7. NCA Manufacturing, Inc.
 - 8. Pottorff.
 - 9. Ruskin Company.
 - 10. Safe Air - Dowco Products.
 - 11. United Enertech.
- B. General Requirements:
 - 1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 - 2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
 - 3. Unless otherwise indicated, use parallel-blade configuration.
- C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 2000 fpm (10 m/s) velocity.
- D. Fire Rating: 3 hours.
- E. Performance:
 - 1. AMCA Certification: Test and rate in accordance with AMCE Publication 511.
 - 2. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - 3. Pressure Drop: 0.05 in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.

4. Velocity: Up to 3000 fpm (15 m/s).
 5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
 6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
- F. Construction:
1. Suitable or horizontal or vertical airflow applications.
 2. Linkage out of airstream.
 3. Frame:
 - a. Hat shaped.
 - b. Stainless steel, with welded corners and mounting flange.
 - c. Gauge is to be in accordance with UL listing.
 4. Blades:
 - a. Roll-formed, horizontal, airfoil, stainless steel.
 - b. Maximum width and gauge in accordance with UL listing.
 5. Blade Edging Seals:
 - a. Silicone rubber.
 6. Blade Jamb Seal: Flexible stainless steel, compression type.
 7. Blade Axles: 1/2-inch- (13-mm-) diameter; stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
 8. Bearings:
 - a. Oil-impregnated stainless steel sleeve.
- G. Mounting Sleeve:
1. Factory installed, galvanized sheet steel.
 2. Length to suit wall or floor application with factory-furnished silicone caulking.
 3. Gauge in accordance with UL listing.
- H. Heat-Responsive Device:
1. Resettable Replaceable, 212 deg F (100 deg C) rated, fusible links.
 2. Electric resettable link and switch package, factory installed, rated.
- I. Master control panel for use in dynamic smoke-management systems.
- J. Damper Actuator - Electric:
1. Electric - 120 V ac or 24 V ac.
 2. UL 873, plenum rated.
 3. Designed to operate in smoke-control systems complying with UL 555S requirements.
 4. Fully modulating with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
 5. Clockwise or counterclockwise drive rotation as required for application.
 6. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C).
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
 7. Environmental Enclosure: NEMA 2.
 8. Actuator to be factory mounted and provided with single-point wiring connection.

- K. Controllers, Electrical Devices, and Wiring:
 - 1. Comply with requirements for electrical devices and connections specified in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Electrical Connection: 115 V, single phase, 60 Hz or 24 V, 60 Hz.
- L. Accessories:
 - 1. Auxiliary switches for signaling fan control position indication.
 - 2. Momentary test switch Test and reset switches, damper remote mounted.
 - 3. Smoke Detector: Integral, factory wired for single-point connection.

2.5 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. DynAir; a Carlisle Company.
 - 4. Elgen Manufacturing.
 - 5. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

2.6 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. FläktGroup.
 - 2. Flexmaster U.S.A., Inc.
 - 3. IAC Acoustics; a division of Sound Seal.
 - 4. McGill AirFlow LLC.
 - 5. Metal Form Mfg/Commercial Acoustics.
 - 6. Pottorff.
 - 7. Price Industries.
 - 8. Ruskin Company.
 - 9. Vibro-Acoustics.
- B. General Requirements:
 - 1. Factory fabricated.
 - 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

- C. Shape:
 - 1. Rectangular straight with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A653/A653M, G90 (Z275), galvanized sheet steel, 0.040 inch (1.02 mm) thick.
- E. Inner Casing and Baffles: ASTM A653/A653M, G90 (Z275) galvanized sheet metal, 22 gauge (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.
- F. Special Construction:
 - 1. Suitable for outdoor use.
 - 2. High transmission loss to achieve STC 45.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
 - 1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 - 2. Dissipative type with fill material.
 - a. Fill Material: Moisture-proof nonfibrous material.
 - b. Erosion Barrier: Polymer bag enclosing fill, heat-sealed before assembly.
 - 3. Lining: None Insert material.
- I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
 - 1. Joints: Lock formed and sealed or flanged connections.
 - 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- J. Accessories:
 - 1. Factory-installed end caps to prevent contamination during shipping.
 - 2. Removable splitters.
 - 3. Airflow-measuring devices.
- K. Source Quality Control:
 - 1. Test in accordance with ASTM E477.
 - 2. Testing of mockups to be witnessed by Architect.
 - 3. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000 fpm (10 m/s) face velocity.
 - 4. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

2.7 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc.

4. Duro Dyne Inc.
 5. DynAir; a Carlisle Company.
 6. Elgen Manufacturing.
 7. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- E. Vane Construction:
1. Single wall for ducts up to 48 inches (1200 mm) wide and double wall for larger dimensions.

2.8 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. DynAir; a Carlisle Company.
 2. METALAIRE, Inc.
 3. United Enertech.
 4. Young Regulator Company.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Aluminum.
- D. Cable: Stainless steel.
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Steel.

2.9 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aire Technologies.
 2. Arrow United Industries.
 3. Cesco Products; a division of MESTEK, Inc.
 4. CL WARD & Family Inc.
 5. Ductmate Industries, Inc.

6. Duro Dyne Inc.
7. Elgen Manufacturing.
8. Flexmaster U.S.A., Inc.
9. McGill AirFlow LLC.
10. Ruskin Company.
11. United Enertech.
12. Ventfabrics, Inc.
13. Ward Industries; a brand of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 7-2 (7-2M), "Duct Access Doors and Panels," and Figure 7-3, "Access Doors - Round Duct."

1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. 0.032-inch (0.81-mm) thick aluminum door panel.
 - d. Vision panel.
 - e. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - f. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - a. 24-gauge- (0.70-mm-) thick galvanized steel or 0.032-inch- (0.81-mm-) thick aluminum <Insert value> frame.
3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
 - a. 24-gauge- (0.70-mm-) thick galvanized steel door panel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 10 inches wg (2500 Pa).
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.10 DUCT ACCESS PANEL ASSEMBLIES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.

3. Flame Gard, Inc.
 - B. Access panels used in cooking applications:
 1. Labeled compliant to NFPA 96 for grease duct access doors.
 2. Labeled in accordance with UL 1978 by an NRTL.
 - C. Panel and Frame: Minimum thickness 16-gauge (1.6-mm) carbon Insert value and steel type steel.
 - D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
 - E. Gasket: Comply with NFPA 96, grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
 - F. Minimum Pressure Rating: 10 inches wg (2500 Pa) positive or negative.
- 2.11 FLEXIBLE CONNECTORS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Duro Dyne Inc.
 4. DynAir; a Carlisle Company.
 5. Elgen Manufacturing.
 6. Ventfabrics, Inc.
 7. Ward Industries; a brand of Hart & Cooley, Inc.
 - B. Fire-Performance Characteristics: Adhesives, sealants, fabric materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested in accordance with ASTM E84.
 - C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - D. Materials: Flame-retardant or noncombustible fabrics.
 - E. Coatings and Adhesives: Comply with UL 181, Class 1.
 - F. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
 - G. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

- H. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- I. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 - 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- J. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.12 DUCT ACCESSORY HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Duro Dyne Inc.
 - 4. DynAir; a Carlisle Company.
 - 5. Elgen Manufacturing.
 - 6. Hardcast; a Carlisle Company.
 - 7. United Enertech.
 - 8. Ventfabrics, Inc.
 - 9. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- C. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.13 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories in accordance with applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116 for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.
- C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- E. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.

- H. Install fire and smoke dampers in accordance with UL listing.
 - I. Connect ducts to duct silencers with flexible duct connectors.
 - J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream and downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-ft. (15-m) spacing.
 - 8. Upstream and downstream from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. For grease ducts, install at locations and spacing as required by NFPA 96.
 - 11. Control devices requiring inspection.
 - 12. Elsewhere as indicated.
 - K. Install access doors with swing against duct static pressure.
 - L. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
 - M. Label access doors according to Section 23 0553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
 - N. Install flexible connectors to connect ducts to equipment.
 - O. For fans developing static pressures of 5 inches wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
 - P. Install duct test holes where required for testing and balancing purposes.
 - Q. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.
- 3.2 FIELD QUALITY CONTROL
- A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors, and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 3346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Flexible ducts, noninsulated.
 - 2. Flexible ducts, insulated.
 - 3. Flexible duct connectors.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. Flexible ducts, noninsulated.
 - 2. Flexible ducts, insulated.
 - 3. Flexible duct connectors.
- B. Product Data Submittals: For each type of product.
- C. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
 - 2. Product Data: For adhesives and sealants, indicating VOC content.
- D. Shop Drawings: For flexible ducts.
 - 1. Include plans showing locations, mounting details, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A and NFPA 90B.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials must be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Duct Council's (formerly, Air Diffusion Council) "ADC Flexible Air Duct Test Code - FD 72-R1" and "Flexible Duct Performance & Installation Standards."
- D. Comply with ASTM E96/E96M.

2.2 FLEXIBLE DUCTS, INSULATED

- A. Standard: Product is to be UL 181 listed and bearing the UL label.
- B. Flexible Ducts, Insulated - Class 1, Two-Ply Vinyl Film Supported by Helically Wound, Spring-Steel Wire; Fibrous-Glass Insulation:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ATCO Rubber Products, Inc.
 - b. Flexmaster U.S.A., Inc.
 - c. JP Lamborn Co.
 - d. Thermaflex; a Flex-Tek Group company.
 - 2. Pressure Rating: 10 inch wg (2500 Pa) positive and 1.0 inch wg (250 Pa) negative.
 - 3. Maximum Air Velocity: 4000 fpm (20 m/s).
 - 4. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
 - 5. Insulation R-Value: Comply with ASHRAE/IES 90.1.
 - 6. Vapor-Barrier Film: Polyethylene.

2.3 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless steel band with stainless steel or zinc-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
- B. Non-Clamp Connectors: Adhesive plus sheet metal screws.

PART 3 - EXECUTION

3.1 INSTALLATION OF FLEXIBLE DUCTS

- A. Install flexible ducts in accordance with applicable details in the following publications:
 - 1. ADC's "Flexible Duct Performance & Installation Standards" for flexible ducts.
 - 2. NAIMA AH116.
 - 3. SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
 - 4. SMACNA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.
- B. Install in indoor applications only. Do not install flexible duct in locations where it will be exposed to UV lighting.
- C. Connect terminal units to supply ducts with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
- D. Connect diffusers and light troffer boots to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.
- E. Connect flexible ducts to metal ducts with liquid adhesive plus tape.
- F. Installation:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.
 - 3. Bends of flexible ducting must not exceed a minimum of one-duct diameter.

4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
5. Install flexible ducts in a direct line, without sags, twists, or turns.
6. Install in accordance with ADC instructions.

G. Supporting Flexible Ducts:

1. Support flexible duct at manufacturer's recommended intervals, but at no greater distance than 4 ft. (1.2 m). Provide sufficient support so that maximum centerline sag is 1/2 in. per ft. (42 mm per meter) between supports. A connection to rigid duct or equipment may be considered a support joint.
2. Install extra supports at bends placed approximately one-duct diameter from center line of the bend.
3. Ducts may rest on ceiling joists or truss supports. Spacing between supports must not exceed the maximum spacing in accordance with manufacturer's written installation instructions.
4. Vertically installed ducts must be stabilized by support straps at a maximum of 72 inches (1800 mm) o.c.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 3400 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fans, centrifugal, inline - square.
2. Fans, plenum.
 - a. Only applicable instance within the air handling unit. See 23 73 13.
3. Fans, plug.
4. Fans, propeller - sidewall mounted.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - b. Rated capacities, furnished specialties, and accessories for each fan.
 - c. Fans:
 - 1) Certified fan performance curves with system operating conditions indicated.
 - 2) Certified fan sound-power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5) Fan speed controllers.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans showing fan rooms and fan system layouts, reflected ceiling plans, and other drawings required to illustrate relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- B. Startup service reports.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fans and ventilators, include the following:
 - 1. Operation in normal and emergency modes.
 - 2. Operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective coverage for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Service Conditions:
 - 1. Ambient Temperature: 72 deg F (deg C).
 - 2. Altitude: 40 feet (m) above sea level.
 - 3. Humidity: 61 deg F (deg C) wet bulb.

2.2 FANS, CENTRIFUGAL, INLINE - SQUARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Twin Cities.

- B. Source Limitations: Obtain square inline centrifugal fans from single manufacturer.
- C. Description: Square-housing in-line centrifugal fans.
- D. Standards: Comply with UL 705.
- E. Housing:
 - 1. Housing Material: See schedule.
 - 2. Housing Coating: See schedule.
 - 3. Housing Construction: Side panels are to be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- F. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.
- G. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- H. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.
- I. Motor Enclosure: Open, drip-proof Totally enclosed, fan cooled Totally enclosed, air over Explosion-proof Insert motor enclosure type.
- J. Accessories:
 - 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 - 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 4. Companion Flanges: For inlet and outlet duct connections.
 - 5. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 6. Motor: Epoxy-coated steel.
 - 7. Belt Guards: Fabricate of prime-coated steel to comply with OSHA and SMACNA requirements for motors with exposed drive belt. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - 8. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.
 - 9. Greenheck Fan Corporation.

2.3 FANS, PLUG

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aerovent; a division of Twin City Fan Companies, Ltd.
 - 2. Chicago Blower Corporation.
 - 3. Cincinnati Fan.
 - 4. Loren Cook Company.
 - 5. New York Blower Company (The).

6. Northern Blower, Inc.
- B. Source Limitations: Obtain plug fans from single manufacturer.
- C. Description:
 1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans, consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
 2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
 3. Factory-installed and -wired disconnect switch.
- D. Standards: Comply with UL 705.
- E. Wheels:
 1. Wheel Configuration: SWSI construction with curved inlet flange and heavy backplate; fastened to shaft with setscrews.
 2. Wheel and Blade Material: Steel Aluminum One-piece fiberglass-reinforced plastic See schedule.
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 Type A Type B Type C.
 3. Wheel and Blade Coating: None Thermoplastic vinyl Epoxy Synthetic resin Phenolic Hot-dip galvanized Powder-baked enamel See schedule Insert manufacturer's name and trade name.
 4. Backward-Inclined Airfoil Blades: Hollow, die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
- F. Shafts:
 1. Statically and dynamically balanced, and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
 2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
 3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- G. Bearings:
 1. Prelubricated and Sealed Shaft Bearings:
 - a. Self-aligning, pillow-block-type ball bearings.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 120,000 Insert number hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 120,000 Insert number hours.
 2. Grease-Lubricated Shaft Bearings, Tapered Roller:
 - a. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 120,000 Insert number hours.
 - c. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 120,000 Insert number hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.
 3. Grease-Lubricated Shaft Bearings, Ball or Roller:
 - a. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
 - b. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 120,000 Insert number hours.

- c. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 120,000 Insert number hours.
 - d. Extended Lubrication Lines: Extend lines to accessible location.
 - H. Belt Drives:
 - 1. Factory mounted, with adjustable alignment and belt tensioning.
 - 2. Service Factor Based on Fan Motor Size: 1.5 1.4 1.3 1.2.
 - 3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - 4. Motor Pulleys: Adjustable pitch for use with motors through 5 Insert number hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with larger motors.
 - 5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; 0.146-inch- (2.7-mm-) Insert dimension thick, 3/4-inch (20-mm) Insert dimension diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
 - 7. Motor Mount: Adjustable for belt tensioning.
 - I. Motor Enclosure: Open, dripproof Totally enclosed, fan cooled Totally enclosed, air over Explosion proof.
 - J. Accessories:
 - 1. Inlet Safety Screen: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 - 2. Safety Enclosure: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 - 3. Belt Guard: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen is welded to steel angle frame or equivalent, prime coated.
 - 4. Inlet Companion Flange: Rolled flanges for duct connections of same material as housing.
 - 5. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 - 6. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
- 2.4 FANS, UTILITY SET
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aerovent; a division of Twin City Fan Companies, Ltd.
 - 2. American Coolair Corporation.
 - 3. Canarm Ltd.
 - 4. Carnes Company.
 - 5. Delhi Industries Inc.
 - 6. JencoFan.
 - 7. Loren Cook Company.

8. New York Blower Company (The).
 9. Peerless Blowers.
 10. PennBarry; division of Air System Components.
 11. Quietaire Inc.
 12. Rupp Air Management Systems.
 13. S & P USA Ventilation Systems, LLC.
- B. Source Limitations: Obtain fan utility sets from single manufacturers.
- C. Description:
1. Factory-fabricated, -assembled, -tested, and -finished, **[belt-]** **[direct-]**driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
- D. Standards: Comply with UL 705.
- E. Housings:
1. Housing Material: Reinforced steel Shaped fiberglass-reinforced plastic Aluminum Stainless steel See schedule Insert material.
 2. Housing Coating: None Thermoplastic vinyl Epoxy Synthetic resin Phenolic Hot-dip galvanized Powder-baked enamel See schedule Insert manufacturer's name and trade name.
 3. Formed panels to make curved-scroll housings with shaped cutoff.
 4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 5. Discharge Arrangement: Fan scroll housing field rotatable to any of seven eight discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.
- F. Wheels:
1. Wheel Configuration: SWSL with hub keyed to shaft.
 2. Wheel and Blade Materials: Steel Aluminum One-piece fiberglass-reinforced plastic Stainless steel See schedule.
 - a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 Type A Type B Type C.
 3. Wheel and Blade Coating: None Thermoplastic vinyl Epoxy Synthetic resin Phenolic Hot-dip galvanized Powder-baked enamel See schedule Insert manufacturer's name and trade name.
 4. Backward-Inclined Airfoil Blades:
 - a. Aerodynamic design.
 - b. Heavy backplate.
 - c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
 5. Backward-Inclined Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.
 6. Backward-Inclined Flat Blades:
 - a. Flat design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.

7. Forward-Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded or riveted at tip flange and backplate.
- G. Shafts:
 1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.
- H. Bearings:
 1. Heavy-duty regreasable ball or roller type in a cast-iron pillowblock housing.
 2. Ball-Bearing Rating Life: ABMA 9, L50 of 200,000 hours L10 of 80,000 hours Insert life.
 3. Roller-Bearing Rating Life: ABMA 11, L50 of 200,000 hours L10 of 80,000 hours Insert life.
 4. Extend grease fitting to accessible location outside of unit.
- I. Belt Drive:
 1. Factory mounted, with final alignment and belt adjustment made after installation.
 2. Service Factor Based on Fan Motor Size: 1.5 1.4 1.3 1.2.
 3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 4. Motor Pulleys: Adjustable pitch for use with motors through 5 Insert value hp; fixed pitch for use with motors larger than 5 Insert number hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," 0.146-inch- (2.7-mm-) Insert dimension thick, 3/4-inch (20-mm) Insert dimension diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- J. Motor Enclosure: Open, dripproof Totally enclosed, fan cooled Explosion proof Insert motor enclosure type.
- K. Accessories:
 1. Inlet and Outlet: Flanged.
 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades, with felt edges in steel frame installed on fan discharge.
 4. Access Door: Gasketed door in scroll with latch-type handles.
 5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 6. Inlet Screens: Removable wire mesh.
 7. Outlet Screens: Removable wire mesh.
 8. Belt Guard: OSHA-compliant, fabricated in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen welded to steel angle frame or equivalent, prime coated.
 9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.

10. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
12. Discharge Dampers: Assembly with parallel opposed blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
13. Grease Collection Trough and Receiver: For restaurant exhaust application.
14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.5 FANS, PROPELLER - SIDEWALL MOUNTED

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. Acme Engineering & Manufacturing Corp.
 2. Aerovent; a division of Twin City Fan Companies, Ltd.
 3. Airmaster Fan; a brand of MAICO.
 4. American Coolair Corporation.
 5. Canarm Ltd.
 6. Carnes Company.
 7. JencoFan.
 8. Loren Cook Company.
 9. Moffitt Corporation.
 10. Peerless Blowers.
 11. PennBarry; division of Air System Components.
 12. Quietaire Inc.
 13. Insert manufacturer's name.
- B. Source Limitations: Obtain sidewall-mounted propeller fans from single manufacturer.
- C. Standards: Comply with UL 705.
- D. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring, with baked-enamel finish coat applied after assembly.
- E. Fan Wheels: Formed-steel blades riveted to heavy-gauge steel spider bolted to cast-iron hub.
- F. Fan Wheel: Replaceable, cast extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- G. Fan Drive, Direct: Direct-drive motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- H. Fan Drive, Belt:
1. Belt drive.
 2. Resiliently mounted to housing.
 3. Statically and dynamically balanced.
 4. Selected for continuous operation at maximum-rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 5. Extend grease fitting to accessible location outside of unit.

6. Service Factor Based on Fan Motor Size: 1.4.
7. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
8. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours Insert life.
9. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
10. Motor Pulleys: Adjustable pitch for use with motors through 5 insert value hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
11. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

I. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Dampers: Counterbalanced, parallel-blade, backdraft dampers factory set to close when fan stops.
3. Motorized Dampers: Parallel-blade dampers with electric actuator wired to close when fan stops.
4. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
5. Wall Sleeve: Galvanized steel to match fan and accessory size.
6. Weathershield Hood: Galvanized steel to match fan and accessory size.
7. Weathershield Front Guard: Galvanized steel with expanded metal screen.
8. Belt Guard: For motor mounted on outside of fan cabinet. Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; 0.146-inch- (2.7-mm-) Insert dimension thick, 3/4-inch (20-mm) Insert dimension diamond-mesh wire screen, welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0500 "Common Work Results for HVAC."
- B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.7 SOURCE QUALITY CONTROL

- A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.
- B. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.
- C. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.
- D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
 - 1. Support duct-mounted and other hanging fans directly from the building structure, using suitable hanging systems as specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
 - 2. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- E. Install units with adequate clearances for service and maintenance.
- F. Label fans in accordance with requirements specified in Section 23 0553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 23 3300 "Air Duct Accessories."
- B. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 PIPING CONNECTIONS

- A. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE:

- A. Perform startup service.
 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 4. Verify that cleaning and adjusting are complete.
 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 7. Adjust belt tension.
 8. Adjust damper linkages for proper damper operation.
 9. Verify lubrication for bearings and other moving parts.
 10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 12. Shut unit down and reconnect automatic temperature-control operators.
 13. Remove and replace malfunctioning units and retest as specified above.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC."

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
 - 3. Fans and components will be considered defective if they do not pass tests and inspections.
 - 4. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVAC fans.

END OF SECTION

SECTION 23 3433.13 - COMMERCIAL AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commercial air-curtain unit.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air curtain units.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.
 - 1. Provide delegated-design submittal for air curtain units indicated to comply with performance requirements and design criteria.
 - a. Detail fabrication and assembly of air-curtain unit mounting assemblies.
 - b. Include design calculations for selecting vibration isolators.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample Warranties: For special warranties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air curtain units to include in operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Furnish one set of filters for each unit installed.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of air curtain units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period (Hot-Water or Steam Heating Units): 18 months.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine work areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for hot-water piping systems to verify actual locations of piping connections before air-curtain installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install air curtains with clearance for equipment service and maintenance.
- B. Equipment Installation: Install air curtains. Comply with requirements for seismic-restraint devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."
- C. Comply with requirements for hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 PIPING CONNECTIONS

- A. Comply with requirements for heating hot-water piping specified in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for steam piping specified in Section 23 2213 "Steam and Condensate Heating Piping" and Section 23 2216 "Steam and Condensate Heating Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."

- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 26 0523 "Control-Voltage Electrical Power Cables."

3.6 ADJUSTING

- A. Adjust motor speed to achieve specified airflow.
- B. Adjust discharge louver and dampers to regulate airflow.
- C. Adjust air-directional vanes.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Tests and Inspections:
 - 1. After installing air curtains completely, perform visual and mechanical check of individual components.
 - 2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
 - 3. Inspect for water leaks.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Air-curtain unit will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial air curtains.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 3600 - AIR TERMINAL UNITS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Modulating, single-duct air terminal units.
 - 2. Exhaust single-duct terminal units.

1.2 ACTION SUBMITTALS

- A. Provide a paragraph by paragraph analysis of this specification and indicate compliance (C), deviation (D), or exception (E) from specification. Submittals that do not contain specification compliance documentation will be returned to the Contractor without review, and will require resubmission.
- B. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Manufacturer shall include terminal unit schedules listing discharge and radiated sound power level, at AHRI Certification Rating Points, for each of the second through seventh octave bands (125-4000Hz) at specified differential static pressures.
 - 4. Manufacturer shall include terminal unit schedules listing discharge and radiated sound power level, at AHRI Certification Rating Points, for each of the second through seventh octave bands (125-4000Hz) at inlet static pressures from 1 to 4 inch water gauge.
 - 5. Manufacturer shall include terminal unit schedules listing radiated sound power level in the occupied space and resulting NC level, based on actual project conditions (including ceiling construction and elevation) at AHRI Certification Rating Points, for each of the second through seventh octave bands (125-4000Hz) at specified differential static pressures.
 - 6. Manufacturer shall include terminal unit schedules listing radiated sound power level in the occupied space and resulting NC level, based on actual project conditions (including ceiling construction and elevation) at AHRI Certification Rating Points, for each of the second through seventh octave bands (125-4000Hz) at inlet static pressures from 1 to 4 inch water gauge.
- C. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
 - 3. Product data showing compliance with ASHRAE 62.1.
- D. Shop Drawings: For air terminal units.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

4. Hangers and supports, including methods for duct and building attachment and vibration isolation.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carrier Global Corporation.
 2. ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America.
 3. Johnson Controls, Inc.
 4. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
 5. Nailor Industries Inc.
 6. Price Industries Limited.
 7. Titus; brand of Johnson Controls International plc, Global Products.
 8. Trane.

- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: Minimum 20-gauge- thick galvanized steel.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article below for "Casing Liner, Flexible Elastomeric" Paragraph.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Outlet: S-slip and drive connections, size matching inlet size.
 - 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.
- E. Velocity Sensors: Multipoint array with velocity inlet sensors.
- F. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide packless attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.
- G. Hydronic Heating Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.08 inch (2.0 mm). Include manual air vent and drain valve. Provide hydronic heating coils for air terminal units scheduled on Drawings.
- H. Direct Digital Controls:
 - 1. Terminal Unit Controller: Pressure-independent, VAV controller and integrated actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
- I. Control Sequence: See Drawings for control sequences.

2.3 EXHAUST SINGLE-DUCT TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anemostat Air Distribution; Anemostat, Inc.; Mestek, Inc.
 - 2. Nailor Industries Inc.
 - 3. Price Industries Limited.
- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud, for exhaust applications where pressurization control via exhaust and supply airflow control is desired.

- C. Casing: Minimum 20-gauge- thick galvanized steel.
 - 1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 2. Air Outlet: S-slip and drive connections, size matching inlet size.
 - 3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.
- E. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide packless attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- F. Direct Digital Controls:
 - 1. Terminal Unit Controller: Pressure-independent, controller and integrated spring-return open spring-return closed fail-in-last-position actuator (actual actuator fail position shall be per drawings), and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Room Sensor: Wall mounted with differential pressure set-point adjustment and access for connection of portable operator terminal.
 - 3. Damper Actuator: 24 V, spring-return open spring-return closed fail in last position. See drawings for actuator fail positions.
- G. Control Sequence: See Drawings for control sequences.

2.4 SOURCE QUALITY CONTROL

- A. AHRI 880 Certification: Test, rate, and label assembled air terminal units in accordance with AHRI 880.
- B. AHRI 880: Test and rate assembled air terminal units in accordance with AHRI 880.
- C. Water Coils: Factory pressure test to 300 psig (2070 kPa) in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" and Section 23 3113 "Metal Ducts" for hangers and supports.
- B. Install air terminal units according to NFPA 90A.

- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- D. Install wall-mounted thermostats.

3.2 PIPING CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Hot-Water Piping: Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 Hydronic Piping Specialties," and connect heating coils to supply piping with shutoff valve, strainer, control valve, and union or flange; and to return piping with balancing valve and union or flange.

3.3 DUCTWORK CONNECTIONS

- A. Comply with requirements in Section 23 3113 "Metal Ducts" for connecting ducts to air terminal units.
- B. Make connections to air terminal units with flexible connectors complying with requirements in Section 23 3300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 26 0523 "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Label each air terminal unit with drawing designation, nominal airflow, maximum and minimum factory-set airflows, and coil type. Comply with requirements in Section 23 0553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

3.8 ADJUSTING

- A. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air terminal unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Rectangular and square ceiling diffusers.
 - 2. Linear slot diffusers.
 - 3. Adjustable bar registers and grilles.
- B. Related Requirements:
 - 1. Section 08 9116 "Operable Wall Louvers" and Section 08 9119 "Fixed Louvers" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Section 23 3300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

- A. Rectangular and Square Ceiling Diffusers :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anemostat Products; a Mestek company.
 - b. Krueger.
 - c. Nailor Industries Inc.
 - d. Price Industries.
 - e. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Aluminum.
4. Finish: Baked enamel, color selected by Architect.
5. Face Size: 24 by 24 inches (600 by 600 mm).
6. Face Style: Plaque.
7. Mounting: [Surface] [T-bar] [Snap in] [Spline] [Mounting panel].
8. Pattern: Fixed.
9. Dampers: Radial opposed blade.
10. Accessories:
 - a. Equalizing grid.
 - b. Plaster ring.
 - c. Safety chain.
 - d. Wire guard.
 - e. Sectorizing baffles.
 - f. Operating rod extension.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Slot Diffuser :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Research Diffuser Products, Inc.
 - b. Anemostat Products; a Mestek company.
 - c. Carnes.
 - d. Krueger.
 - e. Nailor Industries Inc.
 - f. Price Industries.
 - g. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: Aluminum, insulated.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: Baked enamel, black.
6. Finish - Pattern Controller: Baked enamel, black.
7. Finish - Tees: Baked enamel, color selected by Architect.
8. Slot Width: 3/4 inch (19 mm).
9. Number of Slots: Two.
10. Length: 48 inches (1200 mm).
11. Accessories: Plaster frame T-bar slot Center notch T-bar on both sides T-bar clips on both sides.

2.3 REGISTERS AND GRILLES

A. Adjustable Bar Grille :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A-J Manufacturing Co., Inc.
 - b. Anemostat Products; a Mestek company.
 - c. Carnes.
 - d. Dayus Register & Grille Inc.
 - e. Hart & Cooley Inc.
 - f. Krueger.
 - g. METALAIRE, Inc.
 - h. Nailor Industries Inc.
 - i. Price Industries.
 - j. Titus.
 - k. Tuttle & Bailey.
2. Material: Aluminum.
3. Finish: Baked enamel, color selected by Architect.
4. Face Blade Arrangement: Horizontal spaced 3/4 inch (19 mm) apart.
5. Core Construction: Removable.
6. Rear-Blade Arrangement: Vertical spaced 3/4 inch (19 mm) apart.
7. Frame: 1-1/4 inches (32 mm) wide.
8. Mounting Frame: Filter.
9. Mounting: Countersunk screw.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 5123 - GAS VENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Listed double-wall vents.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.
- B. Shop Drawings: For vents.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of hangers and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For special warranty.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.
- B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED TYPE B AND BW VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Metal Products.
 - 2. Cleaver-Brooks.
 - 3. FAMCO.
 - 4. Hart & Cooley Inc.
 - 5. Heat-Fab, Inc.
 - 6. Industrial Chimney Company.
 - 7. LSP Products Group, Inc.
 - 8. M&G DuraVent, Inc.; a member of the M&G Group; Duravent GV Type B Gas Vent.
 - 9. Metal-Fab, Inc.

10. Schebler Co. (The).
 11. Security Chimneys International.
 12. Selkirk Corporation; Selkirk Metalbestos and Air Mate.
 13. Tru-Flex Metal Hose Corp.
 14. Van-Packer Company, Inc.
 15. Insert manufacturer's name.
- B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.
- D. Inner Shell: ASTM B 209 (ASTM B 209M), Type 1100 aluminum ASTM B 209 (ASTM B 209M), Type 3003 aluminum ASTM B 209 (ASTM B 209M), Type 3105 aluminum ASTM A 666, Type 430 stainless steel.
- E. Outer Jacket: Galvanized Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
 2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
 3. Termination: Exit cone with drain section incorporated into riser.
 4. Termination: Antibackdraft.
 5. Termination: Insert termination.

2.2 LISTED TYPE L VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Metal Products.
 2. FAMCO.
 3. Heat-Fab, Inc.
 4. Industrial Chimney Company.
 5. LSP Products Group, Inc.
 6. M&G DuraVent, Inc.; a member of the M&G Group; Pellet Vent Pro.
 7. Metal-Fab, Inc.
 8. Schebler Co. (The).
 9. Security Chimneys International.
 10. Selkirk Corporation; Selkirk Metalbestos and Air Mate.
 11. Simpson Dura-Vent Co., Inc.; Subsidiary of Simpson Manufacturing Co.
 12. Tru-Flex Metal Hose Corp.
 13. Van-Packer Company, Inc.
 14. Insert manufacturer's name.
- B. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

- C. Construction: Inner shell and outer jacket separated by at least a [1/4-inch (6-mm)] [1-inch (25-mm)] [2-inch (50-mm)] [4-inch (100-mm)] airspace filled with high-temperature, [ceramic-fiber] [mineral-wool] insulation.
- D. Inner Shell: ASTM A 666, Type 304 Type 316 stainless steel.
- E. Outer Jacket: Galvanized Aluminized Stainless steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination: Stack cap designed to exclude 90 percent of rainfall.
 - 2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
 - 3. Termination: Exit cone with drain section incorporated into riser.
 - 4. Termination: Insert termination.

2.3 LISTED SPECIAL GAS VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Heat-Fab, Inc.
 - 2. Metal-Fab, Inc.
 - 3. Security Chimneys International.
 - 4. Selkirk Corporation; Selkirk Metalbestos and Air Mate.
 - 5. Z-Flex; a division of the Novaflex Group; Flexmaster Canada Limited.
 - 6. Insert manufacturer's name.
- B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.
- D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
- E. Outer Jacket: Aluminized Stainless steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
 - 2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
 - 3. Termination: Exit cone with drain section incorporated into riser.
 - 4. Termination: Insert termination.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed Type B and BW Vents: Vents for certified gas appliances.
- B. Listed Type L Vent: Vents for low-heat appliances.
- C. Listed Special Gas Vent: Condensing gas appliances.

3.3 INSTALLATION OF LISTED VENTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations.
- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- E. Lap joints in direction of flow.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION

SECTION 23 5216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for boilers.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For energy performance.
- C. Shop Drawings: For boilers, boiler trim, and accessories.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- D. Delegated-Design Submittal: For each boiler.
 - 1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators .
 - b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Fire-Tube Condensing Boilers:
 - a. Heat Exchanger Damaged by Thermal Stress and Corrosion: Nonprorated for 10 years from date of Substantial Completion.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N.
- E. UL Compliance: Test boilers for compliance with UL 795. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- F. Mounting Base: For securing boiler to concrete base.

2.2 FIRE-TUBE CONDENSING BOILERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fulton.
 - 2. AERCO International, Inc.
 - 3. Cleaver-Brooks.
 - 4. Lochinvar, LLC.
- B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base, including ; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water-heating service only. Medium mass design suitable for low flow/variable flow pumping systems.

- C. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where combustion gases transfer heat to the hydronic fluid.
1. The boiler shall be a firetube design, such that all combustion chamber components are within water-backed areas. Watertube boilers will not be accepted.
 2. Furnance to tube connections shall be constructed with low weld intensity, a tube to tube minimum spacing of 2 tube diameters center to center, minimum 1 tube diameter tube to tube ligament, and shall not contain any overlapping welds.
 3. Heat transfer capacity shall be maximized via the use of corrugated firetubes. The corrugation process shall not remove any material from the tubes. Finned, twisted tape, or coil type tube inserts negatively impact ease of maintenance and will not be accepted.
 4. The boiler shall compensate for heat exchanger thermal expansion using a stress relief deflection element external to the pressure vessel shell. The deflection element shall act to protect the boiler tubes and tubesheets from exposure to longitudinal thermal expansion stresses. The deflection element shall not be in contact with flue gases.
 5. Tubesheet to tube weld stresses while the boiler is in operation shall never exceed 1.0 ksi.
 6. The heat exchanger furnace, tubesheets, and firetubes shall be constructed of duplex alloy stainless steel.
 - a. For a long term durability, heat exchanger material of construction must have a minimum Ultimate Tensile Strength of 101 ksi, and a minimum 0.2% Yield Strength of 77 ksi. Weaker materials of construction with reduced strength are not accepted. Boilers seeking an approval must provide documentation that supports this requirement or will be rejected.
 - b. Heat exchangers constructed of cast aluminum, mild steel, cast iron or copper finned tube materials are not accepted.
- D. Exhaust manifold shall be minimum 0.5 in thick stainless steel, ASME designation SA-351 CF3M, and shall be a water-backed design to enhance heat transfer. Dry-back style flue gas condensate collection pan exhaust manifolds are not accepted.
- E. Pressure Vessel: Design and construction shall be in accordance with Section IV of the ASME Code for heating boilers.
1. The shell shall be minimum 0.375" thick steel.
 2. The top head shall be a minimum 0.50" thick steel.
 3. The pressure vessel shall be a counter-flow design with internal water baffling plates.
 4. The boiler return and supply water connections shall be 150# ANSI flanged. The water connections shall not be designed to support an external structural load from the piping system.
 5. The water volume of the boiler shall not be less than 80 gallons.
 6. The maximum water pressure drop across the boiler inlet and outlet connections shall not exceed 5.0 PSI at 289 GPM for 3,000 MBTU/hr boiler.
- F. Fuel/Air Mixture Combustion System. Air and gas pre-mix on the suction side of the fan.
1. Closed-loop oxygen sensor feedback shall automatically adjust the fuel/air ratio. O2 monitoring-only systems that cannot adjust for operation variability shall not be accepted.
 2. Combustion air flow shall be controlled by fan speed and a servo-motor actuated butterfly valve. Fuel flow shall be controlled by a servo-motor actuated butterfly valve. Zero governor or negative regulation systems offer less precision and are not capable of independent air and gas control, and are not accepted.
- G. Burner: Standard natural gas, forced draft, woven fiber mesh design.

1. Turndown: Shall be no less than 15:1.
 2. Excess Air: The burner shall operate at no greater than 7.0% excess O₂ over the entire modulation range to maximize seasonal combustion and thermal efficiencies.
 3. Emissions: When operating on natural gas, the burner shall maintain a NO_x level of <20 ppm, and CO emissions less than 50 ppm, over the complete combustion range at a 3% O₂ correction.
- H. Blower: Variable speed centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.
1. Motors: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - a. Closed-loop brushless DC variable speed motor with hall effect sensor feedback; internal electronic commutation controller with built in speed control and protection features; long life, sealed, ball bearing with high temperature grease.
- I. VMain Fuel Train:
1. A factory mounted fuel train shall be supplied. The fuel train shall be fully assembled and enclosed within the boiler cabinet, complete with factory mounted and wired high and low gas pressure switches in compliance with CSD-1.
- J. Ignition:
1. Direct spark ignition with transformer. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer. Flame rods are not accepted.
- K. Boiler Enclosure:
1. Cabinet: Jacketed steel enclosure with left hinged full height front access door, fully removable latching access panels, mounted on a steel skid with steel plate decking.
 2. Control Enclosure: NEMA 250, Type 1.
 3. Finish: Cabinet shall be powder coated, pressure vessel assembly shall be painted.
 4. Combustion Air: Drawn from inside of the sealed cabinet, preheating the combustion air.
- L. Capacities and Characteristics:
1. Standard capacities shall be based on 100% water.
 2. Minimum Design Water Pressure Rating: 160 psig.
 3. Minimum Return Water Temperature: No minimum temperature requirements.
 4. Maximum Allowable Water Temperature (ASME): 210°F.
 5. Maximum Delta-T: 100°F
 6. Maximum Allowable Operating Setpoint: 200°F
 7. Jacket Losses: External convection and radiation heat losses to the boiler room from the boiler shall comply with IAW ASHRAE 103-2007, and shall not exceed 0.2% of the rated boiler input at maximum capacity.
- M. Flow Switches: Dedicated circulator pumps, or primary-secondary arrangements shall not be required to protect the boiler from thermal shock. Boilers requiring the use of flow switches or primary-secondary piping arrangements will not be accepted.

- N. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.
- O. Trim
1. Safety Relief Valve: ASME rated 60 psig.
 2. Pressure and Temperature Gauge: Minimum 3-1/2" diameter, combination pressure and temperature gauge.
 3. Flue Gas Condensate Drain Trap: A flue gas condensate drain trap shall be provided to prevent positive pressure exhaust gases from entering the boiler room.
 4. Flue Gas Condensate Neutralization: pH neutralization shall be provided.
- P. Controls
1. The boiler electrical control panel shall include the following devices and features:
 - a. 7" color touch screen control display factory mounted on the front cabinet panel door.
 - 1) The control display shall serve as a user interface for programming parameters, boiler control and monitoring; and shall feature a screen saver, boiler status, configuration, history and diagnostics.
 - b. Controls Transformers: 120VAC, 24 VDC, 12 VDC.
 - c. Flame safeguard control with on the boiler shall be integrated with temperature control lead/lag sequencing modular boiler plant functionality..
 - d. All standard controls shall be factory mounted and wired according to UL requirements.
 2. Burner Operating Controls: To maintain safe operating conditions, factory mounted and wired burner safety controls limit burner operation:
 - a. High Limit: A manual reset mechanical Aquastat device shall stop the burner if operating conditions rise above maximum boiler design temperature.
 - b. Low-Water Cut Off: Electronic probe type mounted in the pressure vessel shall prevent burner operation on low water alarm.
 - c. Air Safety Switch: Prevent operation unless sufficient combustion air is proven.
 - d. Blocked Exhaust: Prevent operation in the event of a blocked flue gas exhaust stack.
 3. Boiler Operating Controls and Features:
 - a. Inlet Water Temperature Monitoring.
 - b. Combustion Air Temperature Monitoring.
 - c. Flue Gas Exhaust Temperature Monitoring: Sensor probe shall be stainless steel.
 - d. Proportional Integral Derivative (PID) temperature load control capability for hydronic and domestic hot water in standalone or lead/lag operation.
 - e. Operating temperature sensor for automatic start and stop.
 - 1) The temperature sensor shall have tolerance according to IEC 60751
 - f. Time of day display.
 - g. Customizable boiler name display.
 - h. Two customizable boiler interlock terminals displayed.
 - i. Alarm history for a minimum 100 most recent alarms including status at time of lockout.
 - j. Administrative password protection options.
 - k. Motorized isolation valve control:

- 1) Upon heat demand for the boiler, the control shall provide an enable/open signal.
- 2) After the burner is disabled and upon the heat exchanger delta-T dropping to a user programmable delta-T, the signal will be disabled.
 - a) Boilers which utilize only a time delay close as the only means of valve actuation are unable to optimize for residual heat, and will not be accepted.
- 3) In variable primary arrangements, the control shall hold the lead boiler isolation valve open at all times.
- l. Lead/Lag Control of Modular (Multiple) Boiler Plants: Lead/Lag capabilities shall be integral to the boiler controller for up to 8 boilers installed in the same hydronic loop and shall not require an external panel.
 - 1) The boiler manufacturer shall provide a supply water header temperature sensor.
 - a) The temperature sensor shall have tolerance according to IEC 60751, field installed in the common supply water piping.
 - 2) Lead/lag operation shall not require a master boiler or external control panel. Field wired sensors or communication may be connected to any boiler in the lead/lag sequence.
 - 3) The boilers shall communicate with each other via a private Ethernet/IP addressed network.
 - a) Field wiring between boilers shall be shielded Cat5e or Cat6 Ethernet cable.
 - b) In the event a communication cable becomes damaged or interrupted, communication shall be lost with only one boiler and not the entire lead/lag operation. Daisy chain style wiring lacks this redundancy and shall not be accepted.
- m. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms.
 - 1) Hardwired Contacts:
 - a) Monitoring: Boiler Status, Burner Demand, General Alarm.
 - b) Control with Factory Installed Jumper: Safety Interlock for External Device, Remote Enable, Emergency Stop (E-Stop).
 - c) Remote Setpoint Signal: 4-20 mA or 0-10 VDC.
 - 2) Communication Protocol: A communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.
 - a) A BACnet MSTP and IP protocol communication gateway shall be provided. The BACnet gateway is field installed on a boiler. Additional boilers in the lead/lag system shall not require a dedicated BACnet gateway for the BAS to monitor status. A communication point mapping list shall be provided.
- Q. Electrical Power
 1. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 2. Electrical Characteristics
 - a. Voltage: 120V.
 - b. Phase: Single.
 - c. Frequency: 60 Hz.

- R. Venting
1. The boiler shall be capable of operating with a stack effect not exceeding $-0.04 \cdot W.C.$ and a combined air intake and exhaust venting pressure drop not exceeding: $+1.50 \cdot W.C.$.
 2. Combustion Air Intake: Direct vent the boiler using sealed combustion by drawing combustion air in from the outdoors.
 - a. Sealed Combustion: Smooth-walled galvanized steel, vent termination through wall, with $1/2" \times 1/2"$ mesh bird screen.
 - b. Flue Gas Exhaust: The flue gas exhaust stack shall be AL 29-4C or 316L stainless steel, listed and labeled to UL-1738 / C-UL S636 for use with Category II/IV appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting. Provide shop drawings for venting layout as verified and approved by manufacturer.
- S. Condensate drain piping must be galvanized, stainless steel, or Schedule 40 CPVC. Copper, carbon steel, or PVC pipe materials are not accepted.
1. Provide Manufacturer's standard multiple connection condensate trap and neutralization system.

2.3 SOURCE QUALITY CONTROL

- A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- B. Test and inspect factory-assembled boilers, before shipping, according to latest ASME Boiler and Pressure Vessel Code.
- C. Allow Owner access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance of the Work.
1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Equipment Mounting:
1. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."

- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection (condensate neutralization outlet) to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 23 2116 "Hydronic Piping Specialties."
- E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas-train connection. Provide a reducer if required. Provide line pressure regulator as required.
- F. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
- I. Boiler Venting:
 - 1. Install flue venting and combustion-air intake.
- J. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature or steam pressure.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- B. Boiler will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion , provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Performance Tests:
 - 1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - 3. Perform field performance tests to determine capacity and efficiency of boilers.
 - a. Test for full capacity.
 - b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
 - 4. Repeat tests until results comply with requirements indicated.
 - 5. Provide analysis equipment required to determine performance.
 - 6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
 - 7. Notify Architect 24 hours minimum in advance of test dates.
 - 8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Section 01 7900 "Demonstration and Training."

END OF SECTION

SECTION 23 6423.13 - AIR-COOLED, SCROLL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes packaged, air-cooled, electric-motor-driven, scroll water chillers.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- C. DDC: Direct digital control.
- D. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in Btu/h to the total power input given in watts at any given set of rating conditions.
- E. GFI: Ground fault interrupt.
- F. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- G. I/O: Input/output.
- H. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- I. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit for a single chiller calculated per the method defined by AHRI 550/590 and intended for operating conditions other than the AHRI standard rating conditions.
- J. SCCR: Short-circuit current rating.
- K. TEAO: Totally enclosed air over.
- L. TENV: Totally enclosed nonventilating.

1.4 ACTION SUBMITTALS

- A. Assemble product data and shop drawings in a single submittal file (.pdf) that is bookmarked in coordination with an overall submittal Table of Contents, including and not limited to accessories, variable speed drives, and harmonic filters.
- B. Provide a paragraph by paragraph analysis of this specification and indicate compliance (C), deviation (D), or exception (E) from specification. Submittals that do not contain specification compliance documentation will be returned to the Contractor without review, and will require resubmission.
- C. Product Data: For each type of product.
1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
 2. Performance at AHRI standard conditions and at conditions indicated.
 3. Performance at AHRI standard unloading conditions.
 4. Minimum evaporator flow rate.
 5. Refrigerant capacity of water chiller.
 6. Oil capacity of water chiller.
 7. Fluid capacity of evaporator.
 8. Characteristics of safety relief valves.
 9. Force and moment capacity of each piping connection.
- D. Sustainable Design Submittals:
1. Product Data for EA Prerequisite 3, "Fundamental Refrigerant Management": For refrigerants, indicating compliance with refrigerant management practices.
 2. Refrigerant: Product Data for refrigerants, indicating compliance with refrigerant management practices.
 3. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
 4. Product Data: For energy performance.
- E. A summary page indicating following electrical information. Submittal deficient of this summary sheet will be returned without a review, and will require a resubmission -
1. Power requirement (FLA , MCA , MOCP , Voltage, Phase) for every single module.
 2. Quantity of compressors per module and RLA for each compressor.
 3. Type of compressor and factory installed VFD information (if applicable).
 4. Power requirement of heat trace circuit (FLA , MCA , MOCP , Voltage , Phase).
 5. Circuit diagram indicating wiring information and highlight location(s) where external power is to be provided.
- F. A calculation report that quantifies the de-rate of the array based on actual intended installed condition.
- G. Documentation on recommended Propylene Glycol (30%) fluid quality. Identify organic and inorganic concentration limits of all concerning chemicals to the construction of wetted parts.
- H. Provide factory programmed sequence of operations tailored to and based on project requirements.

- I. Labeled machine array output (including noise information, COP and EER) at design fluid flow rate and design temperature differential -
 1. 95 deg F ambient temperature and Design Day Cooling Load
 2. 85 deg F ambient temperature and Design Day Cooling Load
 3. 45 deg F 50% RH ambient temperature and Maximum Heating Output
 4. 45 deg F 100% RH ambient temperature and Maximum Heating Output
 5. 40 deg F 50% RH ambient temperature and Maximum Heating Output.
 6. 40 deg F 100% RH ambient temperature and Maximum Heating Output.
 7. 35 deg F 50% RH ambient temperature and Maximum Heating Output
 8. 35 deg F 100% RH ambient temperature and Maximum Heating Output
 9. 30 deg F 50% RH ambient temperature and Maximum Heating Output.
 10. 30 deg F 100% RH ambient temperature and Maximum Heating Output.
 11. 25 deg F 50% RH ambient temperature and Maximum Heating Output
 12. 20 deg F 50% RH ambient temperature and Maximum Heating Output
 13. 15 deg F 50% RH ambient temperature and Maximum Heating Output.
 14. 10 deg F 50% RH ambient temperature and Maximum Heating Output.
 15. 0 deg F 50% RH ambient temperature and Maximum Heating Output.

- J. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:
 1. Assembled unit dimensions.
 2. Weight and load distribution.
 3. Required clearances for maintenance and operation.
 4. Size and location of piping and wiring connections.
 5. Diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:
 1. Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - a. Structural supports.
 - b. Piping roughing-in requirements.
 - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
 2. Coordination drawings showing plan, section and elevation views, drawn to 1:48 (1 inch on drawing is 48 inches to scale).
 3. Each view to show screened background with the following:
 - a. Column grids, beams, columns, and concrete housekeeping pads.
 - b. Layout with walls, floors, and roofs, including each room name and number.
 - c. Equipment and products of other trades that are located in vicinity of chillers and part of final installation, such as plumbing systems.

- B. Certificates: For certification required in "Quality Assurance" Article.

- C. Installation instructions.

- D. Source quality-control reports.

- E. Startup service reports.
- F. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touchup Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by chiller manufacturer for use in servicing chiller(s) furnished.
 - 2. Special tools required to service chiller components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Chiller Tool Kit." Text size shall be at least 1 inch (25 mm) high.
 - 4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least 1/2 inch (13 mm) high.
- B. Touchup Paint: 32 oz. (1 L) container of paint used for finish coat. Label outside of container with detailed description of paint to allow for procurement of a matching paint in the future.

1.8 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
- B. Package water chiller for export shipping.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller including refrigerant and oil charge.
 - b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant and oil charge.

- 1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.
- d. Parts and labor.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- B. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 1. Allowable Capacity Tolerance: [Zero] <Insert number> percent.
 2. Allowable Full-Load Energy Efficiency Tolerance: [Zero] <Insert number> percent.
 3. Allowable Part-Load Energy Efficiency Tolerance: [Zero] <Insert number> percent.
- C. AHRI Rating: Rate water chiller performance according to requirements in AHRI 550/590.
- D. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- F. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
- G. Comply with NFPA 70.
- H. Comply with requirements of UL 1995, "Heating and Cooling Equipment," and include label by a qualified testing agency showing compliance.
- I. Operation Following Loss of Normal Power:
 1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to backup power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a backup power source, or through normal power if restored before backup power is brought on-line.
 2. See drawings for equipment served by backup power systems.
 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- J. Outdoor Installations:
 1. Chiller shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a 25 -year period with minimal degradation due to exposure to outdoor ambient conditions.

2. Chillers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past 30 -year period.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Trane.
 2. YORK; a Johnson Controls company.
 3. Swegon.

2.3 MANUFACTURED UNITS

- A. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser with fans, electrical power, controls, and indicated accessories.
- B. Sound-reduction package shall have the following:
 1. Acoustic enclosure around compressors.
 2. Reduced-speed fans with acoustic treatment.
 3. Designed to reduce sound level without affecting performance.

2.4 CABINET

- A. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
- B. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
- C. Casing: Galvanized steel.
- D. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 -hour salt-spray test according to ASTM B117.

2.5 COMPRESSOR-DRIVE ASSEMBLIES

- A. Compressors:
 1. Description: Positive-displacement direct drive with hermetically sealed casing.
 2. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 3. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
 4. Capacity Control: On-off compressor cycling.
 - a. Digital compressor unloading is an acceptable alternative to achieve capacity control.
 5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug or removable magnet in sump, and initial oil charge.

- a. Manufacturer's other standard methods of providing positive lubrication are acceptable in lieu of an automatic pump.
 - 6. Vibration Isolation: Mount individual compressors on vibration isolators.
 - a. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in lieu of each compressor.
 - B. Compressor Motors:
 - 1. Hermetically sealed and cooled by refrigerant suction gas.
 - 2. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
 - C. Compressor Motor Controllers:
 - 1. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
- 2.6 REFRIGERATION
- A. Refrigerant: R-454B. Classified as Safety Group A2L according to ASHRAE 34 - 2022.
 - B. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
 - C. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
 - D. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
 - 1. For multiple compressor assemblies, it is acceptable to isolate each compressor assembly in each circuit in lieu of each compressor.
 - E. Pressure Relief Device:
 - 1. Comply with requirements in ASHRAE 15, ASHRAE 147, and applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Select and configure pressure relief devices to protect against corrosion and inadvertent release of refrigerant.
 - 3. ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger.
- 2.7 EVAPORATOR
- A. Brazed Plate:
 - 1. Direct-expansion, single-pass, brazed-plate design.
 - 2. Type 316 stainless-steel construction.
 - 3. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
 - 4. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.[Furnish flange adapters to mate to flanged piping.]
 - 5. Inlet Strainer: Factory-furnished, 40 -mesh strainer for field installation in supply piping to evaporator. Manufacturer has option to factory install strainer.

- B. Flow Switch: Factory-furnished and -installed, thermal-type flow switch wired to chiller operating controls.
- C. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to minus 20 deg F (minus 29 deg C).
- D. Remote-Mounting Kit: Designed for remote field mounting where indicated. Provide kit for field installation.

2.8 AIR-COOLED CONDENSER

- A. Coil(s) with integral subcooling on each circuit.
- B. Copper Tube with Plate Fin Coils:
 - 1. Construct coils of copper tubes mechanically bonded to aluminum fins.
 - 2. Coating: Corrosion resistant.
- C. Aluminum Microchannel Coils:
 - 1. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - 2. Single- or multiple-pass arrangement.
 - 3. Construct fins, tubes, and header manifolds of aluminum alloy treated with a corrosion-resistant coating.
- D. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- E. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
- F. Fan Motors: TENV or TEAO enclosure, with sealed and permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
 - 1. Overcurrent- and thermal-overload protection not integral to motor is acceptable if provided with chiller electrical power package.
- G. Fan Guards: Removable steel safety guards with corrosion-resistant PVC coating.

2.9 HEAT RECOVERY CONDENSER

- A. Brazed Plate:
 - 1. Type 316 stainless-steel construction.
 - 2. Code Compliance: Tested according to ASME Boiler and Pressure Vessel Code.
 - 3. Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
 - 4. Inlet Strainer: Factory-furnished, 40 -mesh strainer for field installation in supply piping to condenser. Manufacturer has option to factory install strainer.
- B. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the heat recovery condenser to minus 20 deg F (minus 29 deg C).

- C. Insulation: Insulation on heat recovery condenser shall match evaporator.
- D. Controls: Integral to chiller control package.

2.10 INSULATION

- A. Closed-cell, flexible, elastomeric thermal insulation complying with ASTM C534/C534M, Type I for tubular materials and Type II for sheet materials.
 - 1. Thickness: 1-1/2 inches (38 mm).
- B. Adhesive: As recommended by insulation manufacturer.
- C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
 - 1. Apply adhesive to 100 percent of insulation contact surface.
 - 2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
 - 3. Seal seams and joints to provide a vapor barrier.
 - 4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
 - 5. Manufacturer has option to factory or field insulate chiller components to reduce potential for damage during installation.
 - 6. Field-Applied Insulation:
 - a. Components that are not factory insulated shall be field insulated to comply with requirements indicated.
 - b. Manufacturer shall be responsible for chiller insulation whether factory or field installed to ensure that manufacturer is the single point of responsibility for chillers.
 - c. Manufacturer's factory-authorized service representative shall instruct and supervise installation of field-applied insulation.
 - d. After field-applied insulation is complete, paint insulation to match factory-applied finish.

2.11 ELECTRICAL

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to each module of water chiller.
- C. House in a unit-mounted, NEMA 250, Type 3R enclosure with hinged access door with lock and key or padlock and key.
- D. Wiring shall be numbered and color-coded to match wiring diagram.

- E. Factory wiring shall be located outside of an enclosure in a metal raceway. Terminal connections shall be made with not more than a 24-inch (610-mm) length of liquidtight or flexible metallic conduit.
- F. Field power interface shall be to NEMA KS 1, heavy-duty, nonfused disconnect switch. Minimum SCCR according to UL 508 shall be as required by electrical power distribution system, but not less than 65,000 A.
- G. Each motor shall have branch power circuit and controls with one of the following disconnecting means having SCCR to match main disconnecting means:
 - 1. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
- H. Each motor shall have overcurrent protection.
- I. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
- J. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
- K. Power Factor Correction: Capacitors to correct power factor to 0.90 at full load.
- L. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- M. Control Relays: Auxiliary and adjustable time-delay relays, or an integral to water chiller microprocessor.
- N. Service Receptacle:
 - 1. Unit-mounted, 120-V GFI duplex receptacle.
 - 2. Power receptacle from chiller internal electrical power wiring.
- O. Indicate the following for water chiller electrical power supply:
 - 1. Current, phase to phase, for all three phases.
 - 2. Voltage, phase to phase and phase to neutral for all three phases.
 - 3. Three-phase real power (kilowatts).
 - 4. Three-phase reactive power (kilovolt amperes reactive).
 - 5. Power factor.
 - 6. Running log of total power versus time (kilowatt hours).
 - 7. Fault log, with time and date of each.

2.12 CONTROLS

- A. Factory installed and wired, and functionally tested at factory before shipment.
- B. Standalone, microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- C. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.

- D. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, digital display. Display the following:
1. Date and time.
 2. Operating or alarm status.
 3. Operating hours.
 4. Outside-air temperature if required for chilled-water reset.
 5. Temperature and pressure of operating set points.
 6. Chilled-water entering and leaving temperatures.
 7. Refrigerant pressures in evaporator and condenser.
 8. Saturation temperature in evaporator and condenser.
 9. No cooling load condition.
 10. Elapsed time meter (compressor run status).
 11. Pump status.
 12. Antirecycling timer status.
 13. Percent of maximum motor amperage.
 14. Current-limit set point.
 15. Number of compressor starts.
 16. Alarm history with retention of operational data before unit shutdown.
 17. Superheat.
- E. Control Functions:
1. Manual or automatic startup and shutdown time schedule.
 2. Capacity control based on evaporator leaving-fluid temperature.
 3. Capacity control compensated by rate of change of evaporator entering-fluid temperature.
 4. Chilled-water entering and leaving temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water outside-air temperature.
 5. Current limit and demand limit.
 6. Condenser-water temperature.
 7. External water chiller emergency stop.
 8. Antirecycling timer.
 9. Automatic lead-lag switching.
 10. Ice-building mode.
- F. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
1. Low evaporator pressure or high condenser pressure.
 2. Low chilled-water temperature.
 3. Refrigerant high pressure.
 4. High or low oil pressure.
 5. High oil temperature.
 6. Loss of chilled-water flow.
 7. Loss of condenser-water flow.
 8. Control device failure.
- G. BAS System Interface: Factory-install hardware and software to enable system to monitor, control, and display chiller status and alarms.
1. Hardwired I/O Points:
 - a. Monitoring: On/off status, chilled water discharge temperature, heating hot water discharge temperature .

- b. Control: On/off operation, chilled-water discharge temperature set-point adjustment, heating hot-water discharge temperature set-point adjustment.
- 2. Communication Interface: ASHRAE 135 (BACnet) communication interface shall enable control system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through DDC system for HVAC.

- H. Factory-installed wiring outside of enclosures shall be in NFPA 70-complaint raceway. Make terminal connections with liquidtight or flexible metallic conduit.

2.13 ACCESSORIES

- A. Electric Heat Trace or equivalent means of electric heat freeze protection on piping and heat exchangers internal to unit frame.
 - 1. Heat Trace shall be 120V single phase and shall comply with division 23 and division 26 documents for power requirements.
- B. Factory-installed reverse cycle heat pump to enable heating and cooling operation. Heat pump configuration shall include one motorized and two manual valves for each module evaporator.
- C. Variable speed condenser fan control shall be provided for all condenser fans to provide optimum head pressure control and operation in heating or cooling down to 20 deg F.
- D. Factory-furnished spring isolators for field installation.
 - 1. Spring Deflection: 2 inches (50 mm).

2.14 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B209.
- E. Comply with Section 23 0546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000 -hour salt-spray test according to ASTM B117.
 - 1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
 - c. ASTM B3359 for cross hatch adhesion of 5B.
 - 2. Application: Spray.
 - 3. Thickness: 1 mil (0.025 mm).

4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.15 SOURCE QUALITY CONTROL

- A. Perform functional test of water chillers before shipping.
- B. Factory performance test water chillers, before shipping, according to AHRI 550/590.
 1. Test the following conditions:
 - a. Design conditions indicated.
 - b. AHRI 550/590 part-load points.
 2. Allow Owner access to place where water chillers are being tested. Notify Owner 30 days in advance of testing.
- C. Factory test and inspect evaporator and water-cooled condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
- D. For water chillers located outdoors, rate sound power level according to AHRI 370 procedure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before water chiller installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.
 1. Water chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WATER CHILLER INSTALLATION

- A. Coordinate sizes and locations of bases with actual equipment provided. Cast anchor-bolt inserts into concrete bases.
- B. Equipment Mounting:
 1. Install water chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Maintain clearances required by governing code.
- E. Chiller manufacturer's factory-trained service personnel shall charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
- F. Install separate devices furnished by manufacturer and not factory installed.

1. Chillers shipped in multiple major assemblies shall be field assembled by chiller manufacturer's factory-trained service personnel.

3.3 PIPING CONNECTIONS

- A. Comply with requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 23 2300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Where installing piping adjacent to chillers, allow space for service and maintenance.
- D. Evaporator Fluid Connections:
 1. Connect to evaporator inlet with shutoff valve, strainer, thermometer, and plugged tee with pressure gage.
 2. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, and drain connection with valve.
 3. Make connections to water chiller with a flange.
- E. Heat Recovery Condenser Fluid Connections:
 1. Connect to condenser inlet with shutoff valve, strainer, thermometer, and plugged tee with pressure gage.
 2. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with pressure gage, and drain connection with valve.
 3. Make connections to water chiller with a flange.
- F. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.
- G. Connect each chiller vent connection with an automatic or a manual vent, full size of vent connection.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Provide nameplate for each electrical connection indicating electrical equipment designation and circuit number feeding connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high. Locate nameplate where easily visible.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

- B. Connect control wiring between chillers and other equipment to interlock operation as required to provide a complete and functioning system.
- C. Connect control wiring between chiller control interface and DDC system for remote monitoring and control of chillers. Comply with requirements in Section 23 0923 "Direct Digital Control (DDC) System for HVAC."
- D. Provide nameplate on face of chiller control panel indicating control equipment designation serving chiller and the I/O point designation for each control connection. Nameplate shall be laminated phenolic layers of black with engraved white letters at least 1/2 inch (13 mm) high.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
- C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 2. Verify that pumps are installed and functional.
 - 3. Verify that thermometers and gages are installed.
 - 4. Operate water chiller for run-in period.
 - 5. Check bearing lubrication and oil levels.
 - 6. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
 - 7. Verify proper motor rotation.
 - 8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
 - 9. Verify and record performance of chilled- and heat recovery condenser-water flow and low-temperature interlocks.
 - 10. Verify and record performance of water chiller protection devices.
 - 11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- D. Visually inspect chiller for damage before starting. Repair or replace damaged components, including insulation. Do not start chiller until damage that is detrimental to operation has been corrected.
- E. Prepare a written startup report that records results of tests and inspections.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Video record the training sessions and provide electronic copy to Owner.
 - 1. Instructor shall be factory trained and certified.
 - 2. Provide not less than eight hours of training.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 7313.19 - INDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes indoor, custom air-handling units with capacities, characteristics, and configurations indicated on Drawings.
- B. Related Requirements:
 - 1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.

1.2 ACTION SUBMITTALS

- A. Assemble product data and shop drawings in a single submittal file (.pdf) that is bookmarked in coordination with an overall submittal Table of Contents, including and not limited to accessories, variable speed drives, and harmonic filters.
- B. Provide a paragraph by paragraph analysis of this specification and indicate compliance (C), deviation (D), or exception (E) from specification. Submittals that do not contain specification compliance documentation will be returned to the Contractor without review, and will require resubmission.
- C. Product Data: For each air-handling unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in 10 percent speed increments starting at design speed down to minimum speed.
 - b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include dimensions and weight.
 - e. Include motor ratings, electrical characteristics, and motor accessories.
 - 6. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
 - 7. Include certified coil-performance ratings with system operating conditions indicated. Product data to include dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
 - 8. Casing insulation product data and performance ratings.
 - 9. Access door and access panel product data and performance ratings.

10. Paint product data and performance ratings.
 11. Electrical product data and performance ratings.
 12. Metal grating product data and performance ratings.
 13. Steam humidifier product data with performance ratings.
 14. Dampers product data, including housings, linkages, and operators with performance ratings.
 15. Filters product data with performance characteristics.
 16. UV-C lamp systems product data with performance ratings.
- D. Sustainable Design Submittals:
1. Product data showing compliance with ASHRAE 62.1.
 2. Product Data: For air filtration performance.
 3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
 4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
- E. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.
1. Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.
 2. Include plans, elevations, sections, and mounting details.
 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
 4. Detail fabrication and assembly of indoor, custom air-handling units, as well as procedures and diagrams.
 5. Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.
 6. Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.
 7. Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.
 8. Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.
 9. Assembly details of base and casing for units consisting of multiple sections requiring field assembly.
 10. Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.
 11. Base and casing penetration and sealing details for factory-installed conduit.
 12. Base and casing penetration and sealing details for factory-installed piping including coils and steam humidifiers.
 13. Details of casing connections to field-installed ductwork.
 14. Size, shape, and layout of base members including localized support of internal components.
 15. Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.
 16. Recommended points of field attachment with dimensioned locations.
 17. Size and location of each access door, including clearing opening size, with door swing indicated.

18. Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.
19. Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.
20. Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.
21. Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.
22. Mounting details of all internal components, such as fans, filters, and dampers.
23. Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.
24. Location of UV-C lamp systems, service clearances, and mounting details.
25. Location of receptacles, service lights, and switches.
26. Location of motor controllers and disconnect switches.
27. Size and location of junction boxes used for interface with field electrical power.
28. Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types, and ratings.
29. Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.
30. Point-to-point control tubing diagrams including tubing types and sizes, conduit sizes, and connection controls devices.
31. Control panel drawings drawn to scale showing detailed internal layout.
32. Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.
33. Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.
34. .

F. Comparison Schedule:

1. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
2. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
3. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
4. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.
5. Submitted equipment shall have a value for each scheduled value indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Source quality-control reports.
- C. Startup service reports.
- D. Field quality-control reports.

- E. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Bag Filters: One set(s) for each air-handling unit.
 - 2. Cartridge Filters: One set(s) for each air-handling unit.
 - 3. Panel Filters: One set(s) for each air-handling unit.
 - 4. Access Door Gaskets: One set(s) for each unique access door.
- B. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service. See "Accessories" Article for additional requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 FACTORY VISITS FOR PRODUCT INSPECTION

- A. While units are being manufactured, and during factory normal working hours, allow escorted access to manufacturing facility for Owner or Owner's designated representative to verify product compliance with requirements indicated.
 - 1. As many as two persons shall visit factory for product inspection.
- B. Manufacturer shall provide Owner and Architect with written notice at least 30 business days before units go into assembly.
- C. Inspection visits shall be scheduled with manufacturer at least 10 business days before visit.
- D. Personnel making visits for purposes of product inspection shall comply with manufacturer requirements for visitors.

1.8 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.

- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
 - 1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each workday.
 - 2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.

1.9 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One (1) year(s) from date of Substantial Completion.
- B. Extended warranties include, but are not limited to, the following:
 - 1. Complete Air-Handling Unit: Five years from date of Substantial Completion for entire air-handling unit and longer where indicated for individual components.
 - 2. Air-Handling Unit Casing: 30 years from date of Substantial Completion.
 - 3. Motors: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Casing Structural Performance:
 - 1. Floor: Capable of withstanding positive/negative 8 inches wg (2000 Pa) of internal static pressure, without exceeding a deflection of L/300 of span.
 - 2. Walls and Roof: Capable of withstanding positive/negative 8 inches wg (2000 Pa) of internal static pressure, without exceeding a midpoint deflection of L/240 of span.

- F. Casing Leakage Performance: Comply with more stringent of the following requirements:
1. ASHRAE 111, Class 3 leakage or better at plus or minus 8 inches wg (2000 Pa).
 2. Not more than 0.5 percent of the total unit airflow at 8 inches wg (2000 Pa).
- G. Casing Thermal Performance:
1. Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.
 2. Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.
 3. U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1, while considering the effects of metal-to-metal contact and thermal bridging in calculations.
 4. Condensation shall not form anywhere on unit exterior with a 45 deg F supply air at 80 deg F DB / 68 deg F WB exterior ambient. Manufacturer shall supply an external condensation performance line, plotted on the psychrometric chart, based on actual test data. Plot shall show the exterior conditions at which unit will sweat given the design supply air temperature. Manufacturer shall clearly indicate whether the design conditions will or will not result in external condensation forming anywhere on the unit exterior. If the unit will sweat, indicate where sweating will occur. Unit exterior includes the base, base rail, roof, corners, doors, door frames, and under the cooling coil drain pan.
 5. The AHU Manufacturer shall provide, in writing, a guarantee against condensation forming on the unit exterior under then scheduled supply air temperature and the room's extreme ambient air design conditions. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying the units in the field should external condensate form on them. Copies of the guarantee shall be provided to the Engineer and the Owner.
- H. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.
1. Use turning vanes if necessary to direct the air path.
 - a. Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.
 - b. Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.
 2. Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.
 3. Center system components such as coils, fans, and filters, vertically and horizontally, in airstream.
 4. Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.
 5. Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.
- I. Durability Performance: Design and manufacture air-handling units with underlying requirement to provide a highly durable piece of equipment.
1. Unit Life Expectancy: 25 years.

2. Supporting Documentation: Submit documentation showing proposed products to consider and include design features, components, and materials to satisfy requirement.
- J. Extreme Operating Conditions:
1. Corrosive Environments: Air-handling unit manufacturer shall evaluate the quality and potential corrosiveness of air passing through air-handling units and propose additional protective finishes and better-quality materials of a heavier thickness if required to comply with requirements indicated.
 - a. Unless otherwise indicated, air-handling units for HVAC applications may use up to 100 percent of outdoor air or a mix of outdoor air with return air from habitable areas served.
 2. Humidity and Temperatures: Materials and components of air-handling units shall be suitable for use in low and high humidity and temperature extremes when operating under normal and abnormal conditions without permanent degradation or loss in material performance.
- K. Safety:
1. Comply with OSHA regulations.
 2. Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.
 3. Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.
- L. Serviceability:
1. Hoisting Provisions: Fans and motors weighing more than 200 lb (91 kg) to have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.
 2. Mounting Location: Install internal components in readily accessible locations to facilitate ease of service and replacement.
 3. Service Access:
 - a. Internal components shall be serviceable through access sections with doors indicated on Drawings.
 - b. Internal components shall be removable and replaceable through access doors or panels.
 - c. Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.
 4. Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.
- M. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.
1. If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.
 2. If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.

- N. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.

2.2 CAPACITIES AND CHARACTERISTICS

- A. See equipment schedules on Drawings.

2.3 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Enterprises, LLC.
 2. Temtrol; A Nortek Air Solutions Company.
 3. Trane; An Ingersoll Rand Company.
 4. York; a Johnson Controls company.

2.4 UNIT ARRANGEMENT AND CONFIGURATION

- A. Arrangement: Project-specific arrangement and configuration of air-handling units as indicated on Drawings. Do not deviate from requirements indicated without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance.
- B. Mounting Requirements: Units mounted on concrete housekeeping pads.
- C. Multiple Sections: Each air-handling unit shall consist of multiple sections for field assembly to comply with requirements indicated on Drawings.
- D. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
 1. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 2. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.
 3. Limit physical size to fit within available building openings without altering building construction.
 4. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

2.5 AIR-HANDLING UNIT BASE

- A. Performance:
 1. Air-handling unit manufacturer shall design and assemble air-handling unit casing and internal components for attachment and support by air-handling unit structural base.
 2. Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.

3. Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.
 4. Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.
 5. Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.
- B. Structural Member Size:
1. Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.
 2. Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.
 3. Depth of perimeter base members is not less than 8 inches (200 mm) deep.
- C. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed 24 inches (600 mm).
- D. Materials: Structural aluminum, ASTM B209 (ASTM B209M), Alloy 6061 T6.
1. Perimeter Members: I or W beam shapes.
 2. Intermediate Members (Spanning Full Width of Unit): I or W beam shapes.
 3. Cross Members (Spanning Intermediate Members): channel or tube.
- E. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
1. Use welding materials with corrosion properties equal to material being welded.
- F. Welding Procedures:
1. Structural Welding Codes: AWS D1.2/D1.2M for aluminum.
 2. Join structural members to one another using continuous or stitch welds.
 3. After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.
- G. Penetrations through Base Perimeter: Seal weld pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.
- H. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.
1. Joining plate material type to match base.
 2. Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum 1/2 inch (13 mm) thick.
 3. Continuously weld joining plates to each mating end of base.
 4. Joining plates shall not extend beyond outer edge of adjoining base.
 5. Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least 1/2 inch (13 mm).
- I. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated. Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.

2.6 UNIT CASINGS

A. Casing Assembly:

1. Appearance:
 - a. Exposed exterior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than 0.25 inch (7 mm) beyond the exterior skin surface.
 - b. Underside of air-handling units with finished installation exposed to view shall have finished appearance matching casing walls. Casing shall be recessed within the perimeter structural base to provide a single contiguous plane.
 - c. Interior surfaces of casing shall have a neat and finished appearance free of standing seams, exposed reinforcing, and other casing protrusions more than 0.25 inch (7 mm) beyond the skin surface.
2. Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.
3. Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:
 - a. Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211, Alloy 6063 T6.
 - b. Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.
 - c. Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.
 - d. Casings with Stainless Steel Outer and Inner Skins: Stainless steel.
4. Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.
5. Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall. Use double-wall casings to construct air-handling units unless septum casings are required.
6. Penetrations: Seal voids around conduit, piping, and tubing penetrations.
 - a. Walls and Roofs:

- 1) Junction Boxes for routing sensor and power conductors, conduits and wiring -
 - a) Manufacturer shall reference applicable mechanical detail drawings of the air handling unit components and associated mechanical control diagrams indicating diagrammatic locations of all control devices.
 - b) Provide junction boxes at regular intervals along the AHU casing as required to facilitate routing and termination of conduits, conductors and wiring associated with sensors, control devices and power.
 - c) Coordinate exact locations and required opening dimensions with the General Contractor and all applicable sub contractors.
 - d) Size all casing openings to include a minimum of 25 percent additional capacity beyond the required conductor fill to allow for future modifications.
 - e) All penetrations through the AHU casing associated with junction boxes and wiring shall be sealed to maintain airtight and watertight integrity of the unit with air and vapor barrier, moisture/condensation mitigation under all operating conditions.
 - f) Provide removable and non-permanent sealing systems such as neoprene or EPDM grommets, flexible vapor-barrier boots or mechanically fastened access plates with gaskets, arranged to allow for removal and re-installation without damage to casing or conductors.
 - g) Seal all annular spaces with non-hardening vapor barrier compatible sealant or compressible gasketing materials, and provide escutcheon plates on both interior and exterior faces of the casing opening.
- 2) Pipe, and Tube Sizes NPS 3 (DN 80) and Smaller:
 - a) Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.
 - b) Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.
 - c) Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.
- 3) Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.
- b. Floors: Route pipe, and tube within a floor-mounted pipe sleeve.
 - 1) Sleeve:
 - a) Fabricate sleeve of aluminum or stainless steel pipe.
 - b) Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.
 - c) Seal weld sleeve to top of floor for an air- and watertight seal.
 - 2) Seal annular void of sleeve using an adjustable compression seal or nonhardening packing material.
7. Floor Openings with Metal Grating:
 - a. Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.
 - b. Bar Grating:
 - 1) Materials: Use stainless steel grating for aluminum floors.

- 2) Air-handling unit manufacturer shall select depth and thickness of grating bars to limit deflection to 1/360 of span when subjected to a dynamic load of not less than 500 lb (227 kg).
- 3) Industry-standard welded grating with bars at least 1-1/2 inches (38 mm) deep by at least 3/16 inch (5 mm) thick with nominal 1-3/16-inch (30-mm) main bar spacing and 4-inch (100-mm) cross bar spacing.
- 4) Source: Product manufacturer specializing in metal gratings.
- 5) Grating bearing surface shall extend beyond clear opening in floor at least 2 inches (50 mm).
- c. Mounting Frame:
 - 1) Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.
 - 2) Secure grating to frame with threaded hardware, so grating does not move when walked on but can be easily removed from top to gain access behind grating.
 - 3) Continuously weld mounting frame to air-handling unit floor.
 - 4) Fasten mounting frame to air-handling unit floor with hardware and seal attachment air- and watertight.
 - 5) For applications with automatic dampers installed at floor openings, elevate height of mounting frame and grating to enclose entire damper assembly including jackshaft so walk-on surface of grating is above damper assembly.
8. Waterproof Floors: Continuously weld floor joints, seams, and penetrations to completely seal floor. Roll all edges of floor up at least 1 inch (25 mm) to create a shallow tub capable of holding standing water.
9. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.
10. Duct Connections - Elevated Off Casing:
 - a. Terminate with angle flange face elevated 3 inches (75 mm) from exterior surface of casing.
 - b. Flange Thickness: 0.25 inch (6 mm).
 - c. Flange face with holes located not more than 4 inches (100 mm) o.c., starting at corners, and sized for 0.375-inch- (9-mm-) diameter, field-installed hardware.
 - d. Size flange face to mate to full face of duct flange.
 - 1) Clear inside dimension of unit connection to match clear inside dimension of duct.
 - 2) For connections to acoustically lined ducts, increase unit flange face to accommodate thickness of liner so end of duct liner is concealed by air-handling unit flange.
- B. Materials for Outer Skin of Casing Walls and Roofs:
 1. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, stucco-embossed texture finish; minimum (nominal) 0.063 inch (1.6 mm) thick.
 2. Application: See Drawings for application of different materials indicated.
- C. Materials for Inner Skin of Casing Walls and Roofs:
 1. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, smooth finish; minimum (nominal) 0.032 inch (0.8 mm) thick.
 2. Application: See Drawings for application of different materials indicated.
- D. Materials for Floor Walking Surface:

1. Aluminum Diamond Treadplate: ASTM B632/B632M, Alloy 6061 T6; mill finish; minimum (nominal) 0.125 inch (3.2 mm) thick.
 2. Application: See drawings for application of different materials indicated.
- E. Materials for Underside of Floor Insulation:
1. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, smooth finish; minimum (nominal) 0.040 inch (1.1 mm) thick.
 2. Application: See Drawings for application of different materials indicated.
- F. Materials for Internal Walls:
1. Aluminum Solid Sheet: ASTM B209 (ASTM B209M); Alloy 3003-H14, smooth finish; minimum (nominal) 0.063 inch (1.6 mm) thick.
 2. Application: See Drawings for application of different materials indicated.
- G. Surfaces in Contact with Airstream:
1. Comply with ASHRAE 62.1 and NFPA 90A.
- H. Insulation for Casing Walls and Roofs Not Exposed to Airstream:
1. Materials Not Exposed to Airstream: injected or sprayed polyurethane foam insulation with a minimum nominal density of 3 lb/cu. ft. (48 kg/cu. m).
 2. R-Value: Minimum R-13.
 3. Thickness: Minimum 2.5 inches (68 mm), if minimum R-value is met
 4. Insulation shall completely fill the casing cavity so no voids exist.
- I. Insulation for Casing Floors:
1. Materials: injected or sprayed polyurethane foam insulation with a minimum nominal density of 3 lb/cu. ft. (48 kg/cu. m).
 2. R-Value: Minimum R-13.
 3. Thickness: Minimum 2.5 inches (68 mm), if minimum R-value is met.
 4. Insulation shall completely fill the casing cavity so no voids exist.
- J. Access Doors:
1. Application: Install access doors in air-handling units at locations indicated on Drawings.
 2. Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.
 3. Mounting Height: Install bottom of door frame within 2 inches (50 mm) of air-handling unit floor walking surface.
 4. Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than 1.0 cfm (0.47 L/s) per door when tested at 10 inch wg (2500 kPa).
 5. Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing.
 6. Swing: Arrange doors to be opened against pressure unless otherwise indicated on Drawings.
 7. Frame: Extruded aluminum with thermal break with welded mitered corners.
 8. Handles:
 - a. Secure door closed using not less than two roller-style latches with handles located at quarter points along door height.
 - b. If three latches with handles are included, install one at midpoint of door height and equally space others.

- c. Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.
 - d. Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.
 - e. Field adjustable to accommodate changes to fit and gasket compression.
 - f. Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.
9. Hinges: full-length, concealed, stainless steel piano hinge.
10. Gasket:
- a. Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.
 - b. Dual Gaskets: Primary and secondary gasket.
 - c. Location: Install gaskets around entire perimeter of doors or frames.
 - d. Material: EPDM, neoprene, or santoprene.
 - e. Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.
 - f. Service: Field replaceable.
 - g. Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.
11. Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
- a. Width: At least 18 inches (450 mm) clear inside of door frame.
 - b. Height: Full clear height of unit casing up to a maximum height of 60 inches (1500 mm) clear inside of door frame.
 - c. Door sizes indicated on Drawings.
12. Safety Latches and Stops:
- a. Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.
 - b. Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.
13. Tie-Backs: Install tie-backs with retainers on access doors to hold doors in an open position during service.
14. Locks: Include each access door with an integral key lock. Pad locks are unacceptable.
- a. Incorporate key lock into door handle where feature is available.
 - b. A common key shall be used to lock and unlock access doors of all air-handling unit(s).
 - c. Include two keys for each air-handling unit.
 - d. Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.
15. Windows:
- a. Construction: Fabricate windows with frame mounted in access doors of double-glazed safety glass with an airspace between panes and interior and exterior seals.
 - b. Condensation Control: Install desiccant material in airspace between panes if necessary to prevent condensation from forming on glazing.
 - c. Clear Viewing Size: Minimum 8 inches (200 mm), square or round.

- d. Mounting Location: Center window in door width. For doors up to 60 inches (1500 mm) high, locate top of window 6 inches (150 mm) below top of door. For taller doors, locate center of windows at optimal viewing height, approximately 60 inches (1500 mm) above floor adjacent to unit.
- e. Application: Install windows in all access doors.
- 16. Nameplates:
 - a. On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - 1) Dampers.
 - 2) Filters.
 - 3) Cooling Coils.
 - 4) Heating Coils.
 - 5) UV-C Lamp Systems.
 - 6) Supply Fans.
 - 7) Humidifiers.
 - 8) Air-handling unit designation.
 - 9) Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.
 - 10) For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."
 - b. Lettering Size and Style: At least 1-inch- (25-mm-) high, block style.
 - c. Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.
 - d. Attachment: Attach nameplates to door using high-strength bonding cement and stainless steel screws.
 - e. Mounting Location:
 - 1) For access doors with windows, locate nameplate directly below window frame and center in door width.
 - 2) Align nameplates of all doors for uniform placement.
- K. Access Panels:
 - 1. Performance: Leakage as required to satisfy overall unit leakage performance indicated.
 - 2. Fabrication: Formed and reinforced panels of same material and thickness as casing.
 - 3. Fasteners: Adjustable, reusable type for multiple operations without degradation due to reuse. Do not use screws capable of stripping.
 - 4. Arrangement: Panels removable from exterior side of casing.
 - 5. Gasket: EPDM, neoprene, or santoprene similar to access doors, applied around entire perimeter of panels or frames.
 - 6. Location and Size:
 - a. Coils: Oversized access panel to allow removal and replacement without impacting adjacent casing.
 - b. Fans: Oversized access panel to allow removal and replacement of entire fan assembly without impacting adjacent casing.
 - c. Heat Wheels and Heat Exchangers: Oversized access panel to allow removal and replacement of internal components without impacting adjacent casing.
 - d. Humidifiers: Oversized access panel to allow removal and replacement without impacting adjacent casing.

2.7 CENTRIFUGAL PLENUM FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Greenheck Fan Corporation.
 2. New York Blower Company (The).
 3. Twin City Fan & Blower.
- B. Source Limitations: Obtain fans from single source from single manufacturer.
- C. Operating Performance:
1. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - a. Add additional static pressure to fan scheduled total static pressure.
 - b. If fan motor horsepower is increased, notify Architect.
 2. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
 3. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
 4. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
 5. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
 6. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
 7. As a minimum, fans shall have AMCA class indicated on Drawings.
 - a. Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - b. If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - c. AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
 8. Motor starting torque shall exceed fan speed-torque requirements.
- D. Vibration Balance:
1. Each fan/motor assembly shall be factory balanced to AMCA 204, BV-5, Balance Quality Grade G1.0 or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be 10 percent of design speed.
 2. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 3. Submit test reports as an information submittal for Project record.
- E. Operation and Service Requirements:
1. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 2. Design and incorporate features to permit safe, rapid, and economical maintenance.
- F. Fan Base:

1. Mount fan, motor, and drive on a structural-steel or an aluminum base; except, where indicated on Drawings, install fan on a concrete-filled inertia base.
 2. Include base and vibration isolators in accordance with requirements indicated.
 3. Electrically weld the base.
 4. Size and design the base construction to withstand the rigors of shipping and rigging.
 5. Include the base with lifting lugs or holes.
 6. Construct base with gusseted brackets to accommodate spring isolators indicated.
- G. Fan Panel:
1. Construct fan panel of aluminum or powder-coated steel.
 2. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 3. Reinforce and brace fan panel to prevent vibration and pulsation.
 4. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
- H. Fan Inlet and Wheel Cone:
1. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 2. Inlet and wheel cones shall be hyperbolic.
 3. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 4. Fasten inlet cone to fan panel using bolts, nuts, and washers to provide a positive and secure attachment that can be field removable.
 5. Inlet cones that are held in place using retaining clips are unacceptable.
- I. Fan Wheel:
1. Fan blades shall be a true hollow airfoil shape, continuously welded to backplate and wheel cone.
 2. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 3. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 4. Construct fan hubs of cast aluminum or cast iron, ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.
 - a. Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - b. Clean surfaces of castings by blasting, pickling, or other standard method.
 - c. Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - d. Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 5. Hubs shall be keyed and setscrewed to shaft for positive attachment.
 6. Construct the wheel backplates of aluminum.
 7. Statically and dynamically balance fan wheel before fan is assembled.
 8. Select entire rotating assembly so first critical speed is at least 30 percent greater than fan design speed and at least 20 percent greater than maximum AMCA class speed.
- J. Fan Drive:
1. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
 2. Adjust wheel width and diameter to match motor speed while providing performance scheduled.

3. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
 4. Construct motor base and pedestal of aluminum or powder-coated carbon-steel plate.
 5. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.
- K. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.
1. Expanded metal or welded wire welded to a painted carbon-steel frame.
 2. Screens shall comply with OSHA requirements.
 3. Screens shall be constructed of painted carbon steel.
 4. Fasten screens to fan frame for easy removal by maintenance personnel.
- L. Welding:
1. Use AWS- or ASME-certified welders to weld materials required by application.
 2. Where indicated on Drawings, welds shall be continuous full-penetration welds.
- M. Hardware: Hex-head, high-strength 300 series stainless steel.
- N. Nameplates:
1. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
 2. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
 3. Locate nameplates in a highly visible location on motor side of fan.
 4. Engrave the following information on nameplate:
 - a. Manufacturer, address, phone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Fan size.
 - f. Fan schedule equipment designation (may be listed on a separate nameplate if there is insufficient space).
 - g. Design airflow.
 - h. Design static pressure.
 - i. Design fan speed.
 - j. AMCA fan class.
- O. Air-Handling Unit Factory Assembly:
1. Internal Access: Include each fan with internal access from downstream and upstream sides as indicated on Drawings.
 2. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 3. Fan Supports:
 - a. Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - b. Construct frame work from aluminum, galvanized steel, or stainless steel.

2.8 FAN MOTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Baldor Electric Company.

2. Emerson Electric Company.
 3. GE.
 4. Siemens Industry, Inc., Building Technologies Division.
 5. Toshiba Corporation.
 6. US Motors; a NIDEC Corporation brand.
- B. Source Limitations: Obtain motors from single source from single manufacturer.
- C. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
- D. Description: NEMA MG 1, Design B, as required to comply with capacity and torque characteristics; medium-induction motor.
1. Performance:
 - a. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 - b. Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.
 - c. Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.
 - d. Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.
 - e. Service Factor: 1.15.
 - f. Temperature Rise: Match insulation rating.
- E. Enclosure Type: ODP or TEFC.
- F. Shaft Grounding System:
 1. Shaft grounding system to protect bearings from induced voltage.
 2. Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.
 3. Mounting: External or internal to motor enclosure.
- G. Frame:
 1. Frames with integrally cast feet unless other requirements of driven equipment require a different arrangement.
 2. Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48/A48M, Class 25 or better.
- H. Rotor:
 1. Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.
 2. Key rotors to motor shaft.
 3. Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.
 4. Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.

- I. Stator:
 - 1. Copper windings shall be spike resistant to withstand 1600 peak V.
 - 2. Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.
- J. Shaft:
 - 1. Solid shaft fabricated of Type 304 stainless steel, accurately turned, ground and polished, and inspected for accuracy.
 - 2. End of shaft with drilled hole for use in field measurements.
- K. Bearings:
 - 1. Grease-lubricated ball or roller bearings.
 - 2. ABMA 11 L-10 motor bearing life of 100,000 hours.
 - 3. Bearing Lubrication:
 - a. Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.
 - b. Coordinate special requirements that may impact lubrication and include appropriate lubrication.
 - 4. Grease Fittings:
 - a. Equip each bearing housing with an easily accessible grease inlet.
 - b. Fit grease inlets with a grease fitting and protective fitting cap.
 - c. Equip inlets with an automatic grease relief fitting to prevent excessive greasing.
 - d. Equip each bearing housing with grease drain and threaded plug.
- L. Conduit Box:
 - 1. Material same as frame.
 - 2. For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.
 - 3. For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.
 - 4. Coordinate the location and mounting of conduit box with driven equipment manufacturer.
 - 5. Factory mount conduit box on motor.
- M. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.
- N. Motor Leads:
 - 1. Non-wicking type, Class F temperature rating or better, and permanently numbered over entire length for identification.
 - 2. Lead terminals shall be manufacturer's standard.
- O. Condensate Drains:
 - 1. Motor with drain holes at the lowest point for drainage of condensate.
 - 2. Each drain hole with a threaded removable plug.
- P. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.
 - 1. Motor Fan Cover: Same material as frame.

- Q. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.
- R. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.
- S. Nameplates:
1. Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.
 2. Engrave or stamp data on the nameplate.
 3. At a minimum, include nameplate data in accordance with NEMA MG 1. Also include ABMA bearing designation for the drive and opposite end bearing.
- T. Paint: Successfully pass 500 -hour salt spray test for corrosion in accordance with ASTM B117.
- U. Fan Array power wiring: multiple fan motors controlled by one Variable Frequency Drive (VFD)
1. Each fan in the fan array shall be individually wired to an exterior unit mounted NEMA 1 power distribution panel (PDP) for connection to a single VFD sized for the total connected horsepower for all fan motors contained in the fan array. PDP shall include individual fan manual motor protectors, alarm relay, motor overload and individual disconnecting means to disable power to each individual fan in the fan array without disrupting AHU operation for the remaining fans in the fan array. All fans shall be controlled as one single fan. Refer to Section 26 2923 for Variable Frequency Motor Controllers. Manual motor protectors shall meet the following requirements:
 - a. Description: UL 508 Type E self-protected combination manual motor controller installed in an enclosure with a pad-lockable, door-mounted handle mechanism. Door-mounted handle shall have clearly labeled ON, OFF, and TRIP positions. Disconnect switch shall be suitable for motor loads.
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Schneider Electric, Inc.
 - 2) Eaton Corporation
 - 3) Siemens Energy & Automation, Inc.
 - 4) ABB, Control Products.
 - 5) Rockwell Automation, Inc.: Allen-Bradley brand
 - 6) General Electric Company; GE Consumer & Industrial
 - c. Tripping Elements:
 - 1) Adjustable, inverse time-delay thermal overcurrent release for Class 10 overload protection.
 - 2) Fixed, instantaneous release for short-circuit protection.
 - d. Short Circuit Rating: 50kA minimum @ 480V. Short circuit rating must be provided by the manual motor protector assembly and shall not rely on upstream overcurrent protective devices to provide a minimum short circuit rating.
 - e. Operating Temperature: -4 degrees F to 140 degrees F with ambient temperature compensation
 - f. Accessories:
 - 1) Line side insulating barrier as required for UL 508 Type E listing.
 - 2) Short-circuit trip indication as required for UL 508 Type E listing, to differentiate between thermal and short-circuit trips.

- 3) (1) NO auxiliary contact, open when the disconnect switch is in the OFF or TRIP position.
 2. Provide copper wires, bus bars, and fittings throughout, including internal wire of the control transformer. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. All wiring shall be run in plated EMT rigid conduit. Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.
 3. Electrical components, devices, and materials shall be sized in accordance with NEC requirements for 40 degrees C operating conditions.
 4. Liquid tight flexible metallic conduit (LFMC) shall be used across section splits to facilitate unit installation. If internal to the air plenum, flexible metallic conduit or liquid tight type shall be used per NEC..
 5. All conduit connections to boxes and fittings shall be supported not more than 12 inches from connection point. All conduit bends shall be supported not more than 12 inches from each change in direction.
 6. Exposed conduits shall be securely clamped and supported with pipe hangers or galvanized one-hole pipe straps fastened to structure with bolts, screws, and anchors. The spacing of supports for horizontal runs of ¾" conduit or larger shall be not more than 8 feet. The spacing of supports for vertical runs of ¾", and 1 ¼" conduits shall be not more than 7 feet. The spacing of supports for vertical runs of 1 ½" or larger conduits shall be not more than 7 feet.
 7. All unit wiring for external connections shall be terminated on the left hand side of the outgoing terminal blocks.
 8. When multiple vertical rows of terminal boards are located in the same terminal box, a minimum of four inches clear space shall be provided between adjacent vertical rows.
 9. Disconnect switches:
 - a. Disconnect switches shall be heavy duty type, single throw, non-fusible.
 - b. Disconnect switches shall be NEMA3R for outdoor use.
 - c. The operating mechanism on the disconnect switches shall be quick-make, quick-break, and shall not be capable of being restrained by the operating handle during the opening or closing operation.
 - d. Dual interlocks shall interlock the switch box cover when the switch contacts are closed and the switch mechanism is in the "on" position. An interlock release shall be provided to defeat the interlocking mechanism and to permit opening the box cover when the switch contacts are closed, using an external hand tool.
 - e. Switch handles shall be designed for padlocking in the "off" position. All current-carrying metal parts of the switch shall be enclosed.
 10. Provide a disconnect switch for each fan motor; locate switch between the PDP and the fan motor.
 - a. Locate each fan motor disconnect switch within sight of the fan motor that it controls.
- V. Fan Array power wiring: provide a dedicated Variable Frequency Drive (VFD) for each fan motor
1. Refer to Section 26 2923 for Variable Frequency Motor Controllers.
 2. Provide a dedicated factory furnished and installed unit-mounted disconnect switch for each fan motor.
 - a. Locate switch between the VFD and the fan motor.
 - b. Hardwire interlock the operation of the VFD with the position of the associated fan motor disconnect switch.

- c. Locate each fan motor disconnect switch within sight of the fan motor that it controls.
3. Provide copper wires, bus bars, and fittings throughout, including internal wire of the control transformer. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. All wiring shall be run in plated EMT rigid conduit. Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.
4. Electrical components, devices, and materials shall be sized in accordance with NEC requirements for 40 degrees C operating conditions.
5. Liquid tight flexible metallic conduit (LFMC) shall be used across section splits to facilitate unit installation. If internal to the air plenum, flexible metallic conduit or liquid tight type shall be used per NEC..
6. All conduit connections to boxes and fittings shall be supported not more than 12 inches from connection point. All conduit bends shall be supported not more than 12 inches from each change in direction.
7. Exposed conduits shall be securely clamped and supported with pipe hangers or galvanized one-hole pipe straps fastened to structure with bolts, screws, and anchors. The spacing of supports for horizontal runs of ¾" conduit or larger shall be not more than 8 feet. The spacing of supports for vertical runs of ¾", and 1 ¼" conduits shall be not more than 7 feet. The spacing of supports for vertical runs of 1 ½" or larger conduits shall be not more than 7 feet.
8. All unit wiring for external connections shall be terminated on the left hand side of the outgoing terminal blocks.
9. When multiple vertical rows of terminal boards are located in the same terminal box, a minimum of four inches clear space shall be provided between adjacent vertical rows.
10. Disconnect switches:
 - a. Disconnect switches shall be heavy duty type, single throw, non-fusible.
 - b. Disconnect switches shall be NEMA3R for outdoor use.
 - c. The operating mechanism on the disconnect switches shall be quick-make, quick-break, and shall not be capable of being restrained by the operating handle during the opening or closing operation.
 - d. Dual interlocks shall interlock the switch box cover when the switch contacts are closed and the switch mechanism is in the "on" position. An interlock release shall be provided to defeat the interlocking mechanism and to permit opening the box cover when the switch contacts are closed, using an external hand tool.
 - e. Switch handles shall be designed for padlocking in the "off" position. All current-carrying metal parts of the switch shall be enclosed.

2.9 VIBRATION ISOLATION

A. General:

1. Provide fans inside air-handling units with base and vibration isolation indicated on Drawings.

B. Air-Handling Unit Factory Assembly:

1. Use precompression-type height-saving brackets with isolators having 2-1/2-inch (65-mm) deflection or greater, to limit exposed bolt length.
2. Install spring isolators plumb and adjust isolators that are not plumb under operating conditions to make plumb.
3. Adjust isolators to prevent stress transfer to equipment.

4. Verify that installed isolators and mounting systems permit equipment motion in all directions.
5. Restraint fans with isolated thrust resistors to limit displacement to 1/4 inch (6 mm). Design for maximum lateral thrust the fan can develop.
6. Adjust or include additional resilient restraints to flexibly limit fan lateral motion to 1/4 inch (6 mm) during startup and operation of equipment.
7. Anchor restraints to fixed supports having a stiffness greater than the thrust encountered.
8. Include at least 2-inch (50-mm) operating clearance between fan bases and walking surface of air-handling unit floor. Before startup, clean out foreign matter between bases and equipment to prevent short circuit.
9. Flexible Connections:
 - a. Install flexible connections at connections to fans.
 - b. Install flexible connections in accordance with SMACNA standards and manufacturer's written instructions.
 - c. Make fabric joints on the flat run, not the corners, with overlap to provide an area sufficient to make a positive seal.
 - d. Apply adhesive between the fabric layers.
 - e. Attach connections using screws or bolts.
 - f. Reinforce fabric if required to keep fabric from collapsing and impacting airflow into fan.

2.10 HYDRONIC COILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aerofin.
 2. Coilmaster Corporation.
 3. Modine Commercial and Industrial Solutions.
 4. Super Radiator Coils.
- B. Sourcing Option: In lieu of sourcing hydronic coils from a specialty coil manufacturer, air-handling unit manufacturer has option to furnish in-house hydronic coils that achieve equal or better performance while complying with other requirements indicated.
- C. General: Provide air-handling units with hydronic coils where indicated on Drawings.
- D. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins.
- E. Design and Performance:
 1. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
 2. Air pressure drop, water pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
 3. Coils shall be counterflow design, air to fluid. Fluid supply shall enter air leaving side of coil and exit air entering side.
 4. Design coils to be drainable.
 - a. Coils shall have all circuits drainable when coils are installed in horizontal position and level.
 - b. Coil supply and return header shall be furnished with a drain connection at lowest point on header.

5. Design coils to be self-venting.
 - a. Supply connection near bottom of supply header.
 - b. Return connection near top of return header.
 - c. Furnish coil return and supply header with a vent connection at highest point on header.
 6. Coils supply and return piping connections on same end of coil.
 7. Coils shall be rated for system operating pressures and temperatures encountered by installation, but not less than 300 psig (2069 kPa).
 8. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.
- F. Casing and Tube Sheets:
1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch (13 mm) beyond face of fins on both entering and leaving sides.
 2. Casing and Tube Sheet Materials:
 - a. Cooling Coils: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, Type 316L, No. 2D finish.
 - b. Heating Coils:
 - 1) Stainless steel, ASTM A240/A240M or ASTM A480/A480M, Type 316L, No. 2D finish.
 3. Top and Bottom Casings:
 - a. Flange face minimum of 1-1/2 inches (68 mm); double flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch (13 mm).
 - b. Thickness:
 - 1) Coils with Fin Length of up to 72 Inches (1800 mm): Minimum of 12 gauge (2.8 mm) thick.
 - 2) Coils with Fin Length Exceeding 72 Inches (1800 mm): Minimum of 12 gauge (2.8 mm) thick.
 4. End Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Flange face minimum of 1-1/2 inches (68 mm).
 - c. Thickness: Minimum of 12 gauge (2.8 mm) thick.
 5. Intermediate Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Space intermediate tube sheets a maximum of 48 inches (1200 mm) o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - c. Flange face minimum of 1/2 inch (13 mm).
 - d. Thickness: Minimum of 16 gauge (1.6 mm) thick.
 6. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
- G. Fins:
1. Materials:
 - a. Aluminum: 0.0060 inch (0.15 mm) thick.
 2. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 3. Fin Configuration: Flat face fins without ripples.
- H. Headers:

1. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 2. Tube-to-Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness, to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch (3 mm).
 3. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 4. Drains: Include low point of supply and return header with a NPS 1/2 (DN 13) drain connection. Extend copper or red brass pipe through air-handling unit casing and terminate end with male national pipe thread (MNPT). Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 5. Vents: Include high point of supply and return header with a NPS 1/2 (DN 13) vent connection. Extend copper or red brass pipe through air-handling unit casing and terminate end with MNPT. Pipe shall be threaded on both ends to facilitate easy field removal and replacement.
 6. Supply and Return Connections:
 - a. Terminate ends with MNPT.
 - b. Connections to header shall be either copper tube with brazed ASME B16.18 threaded male adapters or red brass pipe with machine-threaded MNPT connections. Pipe shall extend through air-handling unit casing and be threaded on both ends to facilitate easy field removal and replacement.
 - c. Connections NPS 2-1/2 (DN 65) and larger shall have a bronze ASME 16.24 threaded flanges attached to threaded connections to provide for a flanged field connection. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
 7. Protect openings of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into the coil.
- I. Tubes:
1. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper; .
 2. Tube Nominal Diameter: 1/2 or 5/8 inch (13 or 16 mm) before expanding, selected to provide performance indicated.
 3. Tube Nominal Wall Thickness: As required by performance, minimum of 0.035 inch (0.9 mm) thick.
- J. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
1. Tube Return Bend Nominal Wall Thickness: As required by performance, minimum of 0.035 inch (0.9 mm) thick.
- K. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together and more than 30 percent silver when brazing ferrous to non-ferrous materials.
- L. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 316 stainless steel.
- M. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.

2. Manufacturer model number.
3. Serial number.
4. Manufacturing date.
5. Coil identification (indicated on Drawings).
6. Coil fin length.
7. Coil fin height.
8. Coil weight with fluid/without fluid.
9. Coil casing material and thickness.
10. Coil fin material and thickness.
11. Coil tube material and thickness.
12. Coil header material and thickness.

N. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.

O. Air-Handling Unit Factory Assembly:

1. Coil Connections: Extend each coil connection through casing access panel and terminate connections, approximately 4 inches (100 mm) beyond exterior face of access panel, and seal each penetration as indicated. Casing access panels shall be removed and reinstalled with coils installed inside air-handling units.
2. Internal Access: Include each coil with internal access from downstream and upstream sides as indicated on Drawings.
3. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
4. Supports for Coils:
 - a. Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
 - b. Construct framework for cooling coils, from aluminum or stainless steel structural shapes.
 - c. Construct frame work for heating coils from aluminum or stainless steel structural shapes.

2.11 DRAIN PANS

A. General:

1. Include a drain pan for each cooling and heating coil and at other locations indicated.
2. Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.
3. Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.
4. Slope drain pans in multiple directions toward low point drain connection at a uniform slope of at least 1 percent from high point to low point.
5. Include stainless steel blank-offs to prevent air from bypassing around coil.

B. Bottom Drain Pans:

1. Mounting Location, Above Floor: Bottom drain pan shall be installed above air-handling unit floor walking surface. Do not recess drain pan into unit base.
2. Grating: Install removable stainless steel grating on top of drain pan.
3. Double-Wall Construction: Double-wall sheet with space between walls filled with 1-inch (25-mm) insulation.

4. Material: Type 316L stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of 16 gauge (1.6 mm) thick.
5. Minimum Depth: 1.5 inches (38 mm).
6. Extend drain pan beyond air leaving face of coil casing at least 12 inches (150 mm).
 - a. Where moisture eliminators are required to prevent moisture carryover, extend drain pan beyond leaving face of moisture eliminator in lieu of the leaving face of coil.
7. Drain Pan Connection:
 - a. Stainless steel threaded half-coupling welded to lowest point of drain pan.
 - b. Location: Both ends.
 - c. Minimum Nominal Connection Size: NPS 1 (DN 25).
8. Drain Pipe:
 - a. Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - 1) Stainless steel pipe with threaded MNPT ends.
 - b. Extend drain pipe and terminate 3 inches (75 mm) beyond exterior face of casing.

2.12 DIRECT-STEAM-INJECTION PANEL DISTRIBUTION MANIFOLD HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Armstrong International, Inc.
 2. DriSteem.
 3. Nortec Industries Inc.
- B. Source Limitations: Obtain humidifiers from single source from single manufacturer.
- C. Description: Prefabricated, direct-steam panel distribution manifold specially designed for steam dispersion in a short distance.
 1. Horizontal or vertical header with multiple **[vertical]** **[or]** **[horizontal]**, steam-jacketed tubes.
 2. Nozzles/metered orifices in conjunction with nonsteam-jacketed manifolds or punched orifices/no nozzles in conjunction with steam-jacketed manifolds spaced evenly along manifold tubes and providing dry and uniform steam distribution.
- D. Design and Performance:
 1. Absorption distance within 12 inches (300 mm) .
 2. Air Pressure Drop: Less than 0.1 inch wg (25 Pa) at design velocity.
 3. Suitable for pressurized steam applications.
- E. Headers and Distribution Tubes:
 1. Material: Stainless steel, Type 316.
 2. Insulation: Insulated, minimum R-0.5.
- F. Steam Separator: External separator, or separator/baffles integral to header, to provide condensate-free steam to the distribution tubes.
 1. Material: Stainless steel, Type 316.
- G. Steam Trap:
 1. Material: Stainless steel, Type 316.
 2. Type: float and thermostatic.

3. Capacity: Sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) differential pressure.

H. Air-Handling Unit Factory Installation:

1. Air-handling unit manufacturer shall furnish and install humidifiers with the size and capacities indicated on Drawings.
2. Extend humidifier piping through the air-handling unit casing and terminate the connections approximately 4 inches (100 mm) beyond the exterior face.
3. Drain Pans: Install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
4. Provide each humidifier with access for inspection, service, and replacement.
5. Each humidifier shall be removable for replacement through a removable access panel in the air-handling unit casing or an access door.
6. Include a freestanding and self-supporting structural stainless steel framework to support each humidifier.

2.13 CARTRIDGE FILTERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AAF International.
2. Camfil Farr.
3. Flanders Corporation.
4. Koch Filter Corporation.

B. Source Limitations: Obtain filters from single source from single manufacturer.

C. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.

D. Performance:

1. Filtration Efficiency, ASHRAE 52.2 MERV Rating: 14 .
2. Energy Cost Index: Five star rating.
3. Initial Air Pressure Drop: With face velocity of 500 fpm (2.5 m/s), clean filter pressure drop shall not exceed the following:
 - a. MERV 14 and MERV 15A: 0.27 inch wg (68 Pa).
4. Manufacturer-Recommended Final Air Pressure Drop: 1.5 inches wg (375 Pa).
5. Pressure Differential without Failure: 10 inches wg (2500 Pa).
6. Temperature Rating: 175 deg F (79 deg C).

E. Certification:

1. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
2. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
3. UL: UL 900 listed.

F. Construction:

1. Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.
2. Media Frame: Plastic or corrosion-resistant metal.
3. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.

2.14 PLEATED PANEL FILTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AAF International.
 2. Camfil Farr.
 3. Flanders Corporation.
 4. Koch Filter Corporation.
- B. Source Limitations: Obtain filters from single source from single manufacturer.
- C. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
- D. Performance:
1. Filtration Efficiency, ASHRAE 52.2 MERV Rating: 9.
 2. Energy Cost Index: Five star rating.
 3. Initial Air Pressure Drop: With face velocity of 500 fpm (2.5 m/s), clean filter pressure drop shall not exceed the following:
 - a. MERV 9 and MERV 9A:
 - 1) Depth 4 Inches (100 mm): 0.27 inch wg (68 Pa).
 4. Manufacturer-Recommended Final Air Pressure Drop: 1.0 inch wg (250 Pa).
 5. Pressure Differential without Failure: 2 inches wg (500 Pa).
 6. Temperature Rating: 200 deg F (93 deg C).
- E. Certification:
1. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 2. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 3. UL: UL 900 listed.
- F. Construction:
1. Media: Cotton and synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid. Coat media with an antimicrobial agent.
 2. Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.
 - a. Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.
 3. Adhesive: Fire-retardant bonding adhesive where bonding media to casing.

2.15 ASHRAE-RATED FILTER HOLDING FRAMES

- A. Filter Holding Frames for ASHRAE-Rated Filters:
1. Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.
 2. Construct frames of galvanized steel. Use stainless steel frames in applications exposed to corrosive airstreams.
 3. For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.

4. Frame Depth: At least 2.75 inches (70 mm).
5. Gaskets: Continuous, suitable for same operating temperature as filters.
6. Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips shall allow filters to be removed and replaced without use of tools.
7. Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.

B. Air-Handling Unit Factory Installation:

1. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
2. Furnish filter quantity, size, type, and performance indicated on Drawings.
3. Install filter frames in a flat vertical position for horizontal airflow.
4. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
5. Secure individual holding frames together to build a multiple filter bank.
6. Construct aluminum support structure to hold frames and filters.
 - a. Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - b. Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a 200-lb (890-N) lateral force applied at any point on the filter holding frame assembly.

2.16 FILTER GAUGES

- A. Provide a gauge to indicate pressure differential between entering and leaving side of each filter bank. Panel filter bank separate from cartridge filter bank.
 1. Where multiple filters share a common frame, include a separate gauge for each filter bank.
 2. Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.
- B. Gauge shall have a nominal 4-inch- (100-mm-) diameter face.
- C. Select range of gauge to be approximately three times the dirty filter pressure drop.
- D. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
- E. Include static pressure sensors on entering and leaving side of each filter bank.
- F. Air-Handling Unit Factory Assembly:
 1. Mount each filter gauge on exterior surface of unit casing near associated filter sections.
 2. Mount center of gauges 60 inches (1500 mm) above bottom of air-handling unit structural base.
 3. Connect static pressure sensors to filter gauges using aluminum copper or stainless steel tubing and compression type fittings.
 4. Support tubing at intervals not greater than 60 inches (1500 mm) o.c.

2.17 AUTOMATIC DAMPERS

- A. General: Provide air-handling units with automatic dampers where indicated on Drawings.
1. Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
 2. Factory assemble multiple damper sections to provide a single damper assembly of size required by application.
- B. Rectangular Dampers with Aluminum Blades:
1. Source Limitations: Obtain dampers from single source from single manufacturer.
 2. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - b. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, figure 5.3.
 - c. Velocity: Up to [4000 fpm (20 m/s)] [6000 fpm (30 m/s)].
 - d. Temperature: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - f. Damper shall have AMCA seal for both air leakage and air performance.
 3. Construction:
 - a. Frame:
 - 1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch (1.8 mm) thick.
 - 2) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch (25 mm).
 - 3) Width not less than 5 inches (125 mm).
 - b. Blades:
 - 1) Hollow, airfoil, extruded aluminum.
 - 2) Parallel- or opposed-blade configuration as required by application.
 - 3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch (1.8 mm) thick.
 - 4) Width not to exceed 6 inches (150 mm).
 - 5) Length as required by close-off pressure, not to exceed 48 inches (1200 mm).
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - 2) Jambs: Stainless steel, compression type; or replaceable, mechanically attached extruded silicone.
 - d. Axles: 0.5-inch- (13-mm-) diameter, stainless steel, mechanically attached to blades.
 - e. Bearings:
 - 1) Molded synthetic or stainless steel sleeve mounted in frame.
 - 2) Where blade axles are installed in vertical position, include thrust bearings.
 - f. Linkage:
 - 1) Concealed in frame.
 - 2) Constructed of aluminum and stainless steel.
 - 3) Hardware: Stainless steel.
 - g. Additional Corrosion Protection for Corrosive Environments:
 - 1) Include anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch (0.018 mm) thick.

- 2) Axles, damper linkage, and hardware shall be constructed of Type 316L grade stainless steel.

C. Damper Actuators:

1. General:
 - a. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which damper is subjected.
 - b. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
 - c. Total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
 - d. Include one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
 - e. Avoid use of excessively oversized actuators, which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
 - f. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
 - g. Include mounting hardware and linkages for connecting actuator to damper.
 - h. Select actuators to fail in desired position in the event of a power failure.
 - i. Actuator Fail Positions: See Drawings.
 - 1) Outdoor Air: Last position.
 - 2) Supply Air: Open.
2. Type: Motor operated, with or without gears, electric and electronic.
3. Voltage:
 - a. 24 V.
 - b. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - c. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
4. Construction:
 - a. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - b. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - c. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
5. Field Adjustment:
 - a. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 - b. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when actuator is not powered.
6. Two-Position Actuators: Single direction, spring return, or reversing type.
7. Modulating Actuators:
 - a. Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - b. Control Input Signal:

- 1) Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for or 2- to 10-V dc and 4- to 20-mA signals.
- 2) Pulse-Width Modulation (PWM): Actuator drives to a specified position in accordance with a pulse duration (length) of signal from a dry-contact closure, triac sink, or source controller.
- 3) Programmable Multifunction:
 - a) Control input, position feedback, and running time shall be factory or field programmable.
 - b) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - c) Service data, including at a minimum, number of hours powered, and number of hours in motion.
8. Position Feedback:
 - a. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
 - b. Include a position indicator and graduated scale on each actuator indicating open and closed travel limits.
9. Fail-Safe:
 - a. Where indicated, provide actuator to fail to an end position.
 - b. Internal spring return mechanism to drive-controlled device to an end position (open or close) on loss of power.
 - c. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.
10. Integral Overload Protection:
 - a. Provide against overload throughout the entire operating range in both directions.
 - b. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.
11. Damper Attachment:
 - a. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
 - b. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
 - c. Bolt and set screw method of attachment is acceptable only if included with at least two points of attachment.
12. Temperature and Humidity:
 - a. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F (minus 29 to plus 49 deg C).
 - b. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, noncondensing.
13. Enclosure:
 - a. Suitable for ambient conditions encountered by application.
 - b. Provide actuator enclosure with a heater and controller where required by application.
 - c. NEMA 250, Type 2 for all applications except .
 - d. NEMA 250, Type 4 or Type 4X for applications.
14. Stroke Time: Select operating speed to be compatible with equipment and system operation.
 - a. Operate damper from fully closed to fully open within 15 seconds.
 - b. Operate damper from fully open to fully closed within 15 seconds.

- c. Move damper to failed position within 5 seconds.
- d. Actuators operating in smoke-control systems shall comply with governing code and NFPA requirements.
- 15. Sound:
 - a. Spring Return: 62 dBA.
 - b. Non-Spring Return: 45 dBA.

2.18 ANTIMICROBIAL ULTRAVIOLET (UV) LAMP SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Ultraviolet.
 - 2. Steril-Aire, Inc.
 - 3. UV Resources.
 - 4. .
- B. Source Limitations: Obtain lamp systems from single source from single manufacturer.
- C. Description: UV-C lamp system consisting of power supply, wiring, lamp(s), plug(s), and holder(s) used for ultraviolet germicidal irradiation (UVGI) of cooling coil and condensate drain pan.
 - 1. Factory assembled and engineered by a qualified design professional.
- D. Certification: NRTL listed and labeled in accordance with UL 153, UL 1598, and UL 1995; UL Category Code ABQK; HVAC accessories; air-duct mounted.
- E. Performance:
 - 1. Operating Conditions: Suitable for operation in extreme conditions of the airstream encountered.
 - a. Relative humidity range not less than 5 to 100 percent.
 - b. Temperature range not less than 34 to 158 deg F (1 to 70 deg C).
 - c. Velocity range not less than 0 to 600 fpm (0 to 3 m/s).
 - 2. Irradiation Intensity: Install sufficient quantity of UV-C lamps to provide an average irradiation intensity of 500 microwatts/sq. cm over coil face and exposed surfaces of drain pan.
 - 3. Lamp Life: Minimum of 9000 hours.
 - 4. Light Output Degradation: Reduction in light output shall not exceed 15 percent of initial lamp output over the rated lamp life.
- F. Construction:
 - 1. Lamps:
 - a. Type: High output, hot cathode; non-ozone producing.
 - b. Output: UV-C energy, primarily at the 254-nm wavelength with a 360-degree energy distribution.
 - c. Protective Sleeve: Hermetically sealed to provide protection against lamp breakage and to ensure that lamp contents from a broken lamp are contained.
 - d. Labeling: Lamp wattage and model number visibly printed on all lamps.
 - e. Mercury Content: Less than 8 Mg of mercury in each lamp.
 - f. Lamp Sourcing: Commercially sourced from more than one manufacturer for future replacement. Proprietary lamps available from only one manufacturer are unacceptable.

2. Lamp Holders:
 - a. UV- and moisture-resistant materials designed to connect the lamp to the plug and ensure a watertight connection.
 - b. Adjustable positioning.
 3. Wiring Loom: UV-C-resistant jacket materials with internal aluminum/Mylar shield.
 - a. Conduit: Loom covered with NRTL-listed flexible metal conduit, aluminum, or stainless steel.
 4. Power Supply: NRTL listed, single phase, 120 or 277 V ac as indicated, with a programmed rapid start.
 - a. Power Factor: High power factor, Class P, Sound Rated A, Type 1 Outdoor, and with inherent thermal protection and without polychlorinated biphenyl.
 - b. Wiring Harness: Plug and play.
 - c. Electrical Connection: Single electrical connection with service disconnect.
 5. Enclosures: NEMA 250, Type 1 constructed of painted carbon steel.
- G. Air-Handling Unit Factory Assembly:
1. Install UV-C lamp systems in accordance with manufacturer's written instructions.
 2. Location: Install UV-C lamp system array immediately downstream of cooling coil bottom drain pan.
 3. UV-C Lamp System Support Assembly: 300 series grade stainless steel framework rigidly attached to air-handling unit casing and adequately braced to provide ridge support of UV-C lamp systems that will not move or damage when leaned on or bumped into by operators.
 4. Service Access: Lamps shall be easily replaceable from inside the air-handling unit.
 - a. Install access door(s) with window to access UV light. Treat each window and test to confirm UV emitted through the window is below the threshold limits of NIOSH and ACGIH.
 - b. If adequate space is unavailable inside air-handling unit, install UV-C lamp systems on a slide out rail to allow lamp replacement from one exterior side of air-handling unit.
 5. Factory wire UV-C lamp systems internally and terminate at a disconnecting switch on the exterior of the air-handling unit casing.
 - a. Switch to include a lock-out/tag-out feature.
 - b. In addition to disconnecting switch, provide each access door accessible to UV-C lamp systems with a position limit switch wired into UV-C lamp systems power circuit to de-energize power to UV-C lamp systems when door is opened.
 6. Install a caution nameplate at each UV-C lamp systems disconnecting switch that reads: "DANGER, UV LIGHTS - Turn off before entering."
 7. Protection from UV Damage: Materials in direct or indirect (reflected) contact with UV shall be tested and certified as UV tolerant. Any material not certified shall be completely shielded from UV using a certified UV-tolerant material such as metal. UV tolerance shall be capable of performing intended duty for a minimum of 20 years.
 8. Shipping: Remove UV-C lamps after factory testing; package and ship UV-C lamps in protective containers for field installation.
 - a. Label exterior of enclosures with detailed description of container contents, including air-handling unit designation.
 - b. Ship UV-C lamps for each air-handling unit in separate containers.
- H. UV-C Lamp System Irradiance Monitoring:
1. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.

2. General: UVGI monitoring consisting of sensor(s) and controller to measure and locally display UV output irradiance in absolute output (microwatts/sq. cm) and user-defined percentage of relative output.
 3. Measurement Range: Suitable for highest measured irradiance encountered by application, but not less than 20,000 microwatts/sq. cm.
 4. NIST traceable calibration.
 5. Remote Monitoring Signal: 4- to 20-mA output signal for remote monitoring.
- I. UV-C Lamp System Status Monitoring:
1. Sourcing: Furnished by UV-C lamp system manufacturer with UV-C lamp systems.
 2. Monitors operating status of UV-C lamps by measuring change in electrical current.
 3. On/off status of lamps displayed by LED lights on face of local display unit.
 4. Remote Monitoring Signal: On/off status relays for remote monitoring.
- 2.19 AIR-HANDLING UNIT FACTORY DRAIN PIPING AND PIPING INSULATION
- A. General:
1. Air-handling unit manufacturer to factory install piping inside air-handling units.
 2. If more than one material is listed, material selection is by air-handling unit manufacturer.
- B. Aluminum Piping:
1. Pipe: Aluminum ASTM B241/B241M, Grade 1061, Temper T6, seamless longitudinal joints with beveled or plain ends; and wall thickness as indicated under applications.
 2. Fittings: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1 Class 150; threaded ends.
 3. Flanges: Cast aluminum, ASTM B26/B26M, Grade 356, Temper T6, ASME B16.1, Class 150 including bolts, nuts, washers, and gaskets of the following end connections and facings:
 - a. Threaded end connections for threaded joints, welding-neck with butt-joint for welded joints, and blinds for use with flanged joints requiring close-off.
 4. Unions: Cast-aluminum, ASTM B26/B26M, Grade 356, Temper T6, hexagonal-stock body; female NPT threaded ends.
- C. Copper Tubing:
1. Tubing: Drawn temper, ASTM B88, Type L (ASTM B88M, Type B).
 2. Fittings: Wrought-copper and copper-alloy, ASME B16.22, pressure fittings.
 3. Unions: Cast-copper-alloy, MSS SP-123, hexagonal-stock body; female NPT threaded ends
 4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux in accordance with ASTM B813.
- D. Drain Pan Piping:
1. Schedule 40 aluminum or stainless steel pipe with threaded ends or copper tube with soldered threaded male adapters.
 2. Factory install drain piping for drain pan(s). Install a dedicated drain pipe for each drain pan serving different air-handling unit internal components. Where multiple drain pans serve like components interconnect drain piping to a single drain pipe for field connection.

- a. Where interconnecting cooling coil condensate drain pans from upstream and downstream sides of cooling coil, provide pipe with a water seal trap configured to prevent air bypass.
- b. Terminate pipe with a threaded pipe cap 3 inches (75 mm) beyond exterior face of air-handling unit casing. Threaded pipe cap material to match pipe material.
- c. Drain pipe size to match size of drain pan connection.

2.20 DRAINS

A. Floor Drains:

1. Drain Body: Fabricate floor drain body of NPS 4 (DN 100) or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least 4 by 4 inches (100 by 100 mm) of material at least 0.1 inch (3 mm) thick.
2. Drain Connection: Weld a nominal NPS 2 (DN 50) half coupling in side of drain body located within 1 inch (25 mm) from bottom.
3. Drain Cover: Perforated plate, at least 0.1 inch (3 mm) thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.
4. Fluid Seal: Weld floor drain body to air-handling unit floor for a watertight installation.
5. Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.
6. Application: Install floor drains in air-handling unit floors at locations indicated on Drawings.
7. Application: Install floor drains in air-handling unit floors of all sections.
8. Application: Install floor drains in air-handling unit floors of coil and humidifier sections and associated access sections.

2.21 FACTORY ASSEMBLED ELECTRICAL

A. Factory install UV-C and switches, service light fixtures and switches, and receptacles for each air-handling unit.

1. Locate in a convenient and field-accessible location.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: 3/4 inch (20 mm).
 - b. Materials: Stainless steel.
 - c. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
 - d. Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.
 - e. Wire:
 - 1) Copper, rated for 600 V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: No. 12 AWG.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
 - f. Boxes, Conduit Outlet Bodies, and Enclosures:
 - 1) Located in Airstream: NEMA 250, Type 4 .
 - 2) Located on Exterior of Air-handling Unit Casing: NEMA 250, Type 1.

- g. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
 - h. UV-C Lamp System Applications: Wire all UV-C lamp systems located in the same air tunnel to a single circuit.
 - i. Service Lighting Applications:
 - 1) Provide quantity of 20-A branch circuits required to power service light fixtures.
 - 2) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 3) Factory install a field power junction box for interfacing air-handling power for service lighting with single-point field power wiring connection.
 - j. Receptacle Applications:
 - 1) For air-handling units consisting of multiple stacked tiers, provide separate circuits for top and bottom tiers of air-handling units.
 - 2) Factory wire receptacles to a field power junction box for interfacing air-handling power for receptacles with a single-point field power wiring connection.
- B. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
- 1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
 - 2. Three pole, fused.
 - 3. 600 V rated.
 - 4. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
 - 5. Enclosure: NEMA 250, Type 1.
 - 6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 - 7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 - 8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 - 9. Include a solid neutral as required by authorities having jurisdiction.
 - 10. Disconnect switch shall have a ground lug for ground wire termination.
 - 11. Operating handle shall be lockable in open position.
 - 12. Horsepower rated.
 - 13. Feed through or double lugged.
- C. Field Power Junction Box: Factory-install junction box with internal wire terminal block mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
- D. Service Light Fixtures:
- 1. Fluorescent Luminaires:
 - a. Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - b. High-impact, UV-stabilized fiberglass-reinforced polyester housing, high-impact acrylic lens.
 - c. Two, cool white, T 8HO lamps, and an electronic ballast.
 - 2. LED Luminaires:

- a. Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - b. High-impact, UV-stabilized fiberglass housing and acrylic lens.
 - c. Light Color: 5000 K.
 - d. Light Output: 4000 lumens.
 - e. Driver: 1 percent dimming.
 3. Application: Provide service light fixtures where indicated on Drawings.
 4. Application: Provide one service light fixture in each accessible section of air-handling units.
 5. Application: Provide one service light fixture in fan, coil filter sections of air-handling units.
- E. Toggle Switches for Service Light Fixtures:
1. Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 2. Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 3. Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 4. Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 5. Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - a. Description: Handle illuminated when switch is on.
 6. Toggle Switch Box and Cover: Mount toggle switch in a cast-aluminum outlet box with cast-aluminum cover.
 7. Application: Factory install service light switches at locations indicated on Drawings.
 8. Application: Factory install a single service light switch to switch all service light fixtures from a single location.
 9. Application:
 - a. Factory install a service light switch for each service light fixture or group of service light fixtures accessible from a single access door adjacent to the access door.
 - b. Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.
 10. Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.
- F. Receptacles:
1. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 - a. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
 - b. Configuration: NEMA WD 6, Configuration 5-20R.
 - c. Standards: Comply with UL 498 and FS W-C-596.
 2. Duplex GFCI Receptacles, 125 V, 20 A:
 - a. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - b. Configuration: NEMA WD 6, Configuration 5-20R.
 - c. Type: Non-feed through.
 - d. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
 3. Receptacle Box and Cover: Mount receptacle in a cast-aluminum outlet box with cast-aluminum cover.

4. Applications: Factory install a receptacle in a convenient and field-accessible location on air-handling unit exterior of casing near access doors accessing fans.

G. Power Supply to Fan Motors: As indicated on Drawings.

H. Power Supply to Fan Motors: Factory install a disconnect switch for each fan motor.

1. Locate in a convenient and field-accessible location on unit exterior.
2. Installation shall comply with NFPA 70.
3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: 3/4 inch (20 mm).
 - b. Materials: Metal, corrosion resistant and constructed of stainless steel.
 - c. Motor Termination: Flexible conduit, NRTL listed, not to exceed 36 inches (900 mm) long.
 - d. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware constructed of stainless steel.
 - e. Wire:
 - 1) Copper, rated for 600 V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: No. 12 AWG.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
 - f. Boxes, Conduit Outlet Boxes, and Enclosures:
 - 1) Located on Exterior of Air-Handling Unit Casing: NEMA 250, Type 1.

I. Disconnect Switches:

1. Specification Grade; "Heavy Duty Type"; "quick-make," "quick-break" construction.
2. Three pole, fused.
3. 600 V rated.
4. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
5. Enclosure: NEMA 250, Type 1.
6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
9. Include a solid neutral as required by authorities having jurisdiction.
10. Disconnect switch shall have a ground lug for ground wire termination.
11. Operating handle shall be lockable in open position.
12. Horsepower rated.
13. Feed through or double lugged.

2.22 FACTORY-ASSEMBLED CONTROLS

A. General:

1. Air-handling unit manufacturer shall furnish and factory install control instruments, control power circuit, control transformers, power supplies, wiring, tubing, raceways, and control panels.

2. Provide for a single-point field connection to 277-V electrical power for all factory-installed controls. Terminate power connection with a toggle switch mounted in control panel.
 3. Control panel shall serve as field tie-in point for all electric damper actuators, and control instruments located within air-handling unit. Controls for control dampers, control valves, and instruments installed in ductwork and piping are not included as part of air-handling unit factory-installed controls.
 4. Control instruments shall be installed in accordance with manufacturer's written instructions.
 5. Control panel shall house flow, moisture, pressure and temperature transmitters, transformers, dc voltage power supplies, and wiring terminal strip.
 6. Carbon dioxide transmitters shall be mounted on air-handling unit casing exterior with sensor port exposed to the airstream.
 7. Factory install the following control instruments:
 - a. Flow station and flow transmitter for each fan.
 - b. Pressure sensors (inlet and discharge) and one combination pressure differential transmitter, switch, and controller for each filter bank installed in the air-handling unit.
 - c. Pressure sensor and combination pressure differential transmitter, switch, and controller at the inlet of each fan.
 - d. Pressure sensor and combination pressure differential transmitter, switch, and controller at the discharge of each fan.
 - e. Carbon dioxide sensor/transmitters at locations indicated on Drawings.
 - f. Moisture and temperature sensors and transmitters at locations indicated on Drawings.
 - g. Temperature switches at locations indicated on Drawings.
 - h. Control instruments indicated on Drawings.
- B. Wire and Cable:
1. Single Conductor Control Wiring above 24 V:
 - a. Wire size shall be at least No. 16 AWG.
 - b. Conductor shall be 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch (50- to 65-mm) lay.
 - c. Conductor insulation shall be 600 V, Type THWN or Type THHN, 90 deg C in accordance with UL 83.
 - d. Conductor colors shall be black (hot), white (neutral), and green (ground).
 2. Single Twisted Shielded Instrumentation Cable above 24 V:
 - a. Wire size shall be minimum No. 18 AWG.
 - b. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch (50- to 65-mm) lay.
 - c. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 - d. Shielding shall be 100 percent 0.35/0.5-mil aluminum/mylar tape, helically applied with 25 percent overlap, and aluminum side in with a No. 18 AWG-7/26 tinned copper drain wire.
 - e. Outer jacket insulation shall have a 600-V, 90 deg C rating and shall be Type TC cable.
 - f. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
 3. Single Twisted Shielded Instrumentation Cable 24 V and Lower:
 - a. Wire size shall be minimum No. 18 AWG.

- b. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2-1/2-inch- (50- to 65-mm) lay.
 - c. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 - d. Shielding shall be 100 percent 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with a No. 20-22 AWG tinned copper drain wire.
 - e. Outer jacket insulation shall have a 300-V, 105 deg C rating and shall be Type PLTC cable.
 - f. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red, and white.
4. Wire and Cable Installation:
- a. Comply with manufacturer's written instructions and NFPA 70.
 - b. Grounding shall be in accordance with IEEE C2. Ground wire shall be copper. Demonstrate ground resistance.
 - c. Wiring and cables shall be installed in conduit. Exposed wire and cable are unacceptable.
 - d. Wire and cables may be grouped in a common raceway, except do not group wires and cables from different voltages.
 - e. Install control wiring in a separate conduit from power wiring.
 - f. Wiring shall be continuous from terminal to terminal without splices.
 - g. Do not install low-voltage wire and cable closer than [12 inches (300 mm)] <Insert distance> from line voltage electrical power wire and cables. Provide an installation free of EMI.
 - h. Use insulated spade lugs for wiring connection to screw terminals.
 - i. Use shielded cable to transmitters.
 - j. Terminate wiring and cables within a control panel, within instrument housing, or in a junction box. Clamp the cable over the jacket, in the junction box. Individual conductors in the stripped section of cable shall be slack between clamping point and terminal block.
 - k. Terminate wire and cable in control panel with terminal blocks.
 - l. Identify each wire and cable on each end and at each terminal with a number-coded identification tag. Each wire and cable conductor shall have a unique tag.
 - m. Perform continuity and meager testing on wiring and cable.
- C. Pitot Tube Airflow Stations:
1. Fan Inlet Airflow Sensor (Piezometer Ring):
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) ebm-papst Inc.; Instrumented Inlet Ring.
 - 2) Greenheck Fan Corporation; Sure-Aire.
 - 3) Twin City Fan & Blower; Piezometer Ring.
 - b. Source Limitations: Obtain sensors from single source from single manufacturer.
 - c. Provide fans with airflow measurement integral to fan inlet cones for continuously measurement of air volume flow rate.
 - d. Fan inlet airflow sensor shall contain multiple pressure sensor points strategically placed along the circumference of the inlet cone and internally connected to an averaging ring manifold located behind the inlet cone.
 - e. Sensor points shall neither protrude beyond the surface of the inlet cone nor be adversely affected by particle contamination present in the airstream.

- f. Sensor shall produce steady, non-pulsating signals to achieve accuracy within 5 percent of actual airflow.
 - g. Sensor shall be non-intrusive and not impact fan performance.
 - h. Product shall be a standard offering of fan manufacturer and include published literature with supporting test data to validate sensor performance.
- D. Flow Transmitters for Pitot Tube Sensors:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Air Monitor Corporation; Veltron II.
 - 2. Source Limitations: Obtain sensors from single source from single manufacturer.
 - 3. Receives total and static pressure signals from a flow element, amplify, extract the square root, and scale the signal to produce a 4- to 20-mA dc output signal linear to airflow.
 - 4. Housed in NEMA 250, Type 1 enclosure.
 - 5. Assembly constructed so that shock, vibration, and pressures surges of up to 1 psig (6.9 kPa) will neither harm transmitter nor affect its accuracy.
 - 6. Provide transmitter with an automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. Automatic zeroing circuit shall re-zero transmitter to within 0.1 percent of true zero.
 - 7. Performance:
 - a. Range: At least 20 percent below minimum airflow and 20 percent greater than design airflow.
 - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
 - c. Accuracy: Within 0.10 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
 - 8. Equip transmitter with an integral digital LED or LCD for continuous indication of airflow.
 - 9. Install in control panel.
- E. Control Transformers:
 - 1. Size each transformer for the total connected load, plus an additional 25 percent of the connected load.
 - 2. Each transformer shall be at least 100 VA.
 - 3. Provide transformer with both primary and secondary fuses.
- F. 25-V dc Power Supply:
 - 1. Plug-in style suitable for mating with a standard eight-pin octal socket.
 - 2. Enclose circuitry within a housing.
 - 3. Include line and load regulation to ensure a stable output. To protect both power supply and load, include power supply with an automatic current limiting circuit.
 - 4. Performance:
 - a. Output voltage nominally 25 V dc within 5 percent.
 - b. Output current up to 100 mA.
 - c. Input voltage nominally 120 V ac, 60 Hz.
 - d. Load regulation within 0.5 percent from 0- to 100-mA load.
 - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.
- G. Instrument Identification:

1. Engraved tag bearing instrument identification.
 - a. Each tag identifying an instrument shall have a unique identification that does not match identification of a similar device.
 - b. Tag field instruments identified by equipment being controlled or monitored, followed by point identification used on I/O schematics.
 - c. Example: DDC-AHU-01.01; PDIT1.
 2. Letter size shall be minimum 1/4 inch (6 mm) high.
 3. Letter type shall be sans serif gothic bold style.
 4. Lettering and background color scheme shall be white letters on black background.
 5. Tag shall be engraved phenolic constructed of three layers of pressure rigid laminate. Top and bottom layers are color-coded, contrasting white center is exposed by engraving through outer layer. Engrave both sides. Material shall be stain proof, heat resistant, non-conductive, or non-corrosive.
 6. Tag shall be fastened to equipment/instrument with drive pins or attached with a stainless steel chain.
 7. Instruments furnished with identification tags provided by original manufacturer do not require an additional tag.
- H. Checkout Procedures:
1. Check instruments for proper location and accessibility.
 2. Check instruments for proper installation for direction of flow, elevation, orientation, and other applicable considerations.
 3. Damper Check-out: Verify that proper blade alignment, either parallel or opposed, has been provided.
- I. Calibration and Adjustment:
1. Calibrate every instrument.
 2. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 3. Equipment and procedures used for calibration shall meet requirements of instrument manufacturer's written instructions. Test equipment used in calibration of instruments shall have an accuracy at least double that of instrument being calibrated.
 4. Calibrate each instrument in accordance with the accuracy outlined in instruction manual supplied for instrument by manufacturer.
 5. Control System Inputs and Outputs:
 - a. Check analog inputs using a precision voltage or current source at zero, 50, and 100 percent of span.
 - b. Check analog outputs using a milliamper meter at zero, 50, and 100 percent output.
 - c. Check digital inputs using a jumper wire.
 - d. Check digital outputs using an ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at zero, 50, and 100 percent of span using a precision-resistant source.
 6. Flow: Set differential pressure flow transmitters for zero and 100 percent values with three-point calibration accomplished at 100, 50, and 90 percent of span.
 7. Gas: Calibrate gas transmitters at zero, 50, and 100 percent of span.
 8. Humidity: Calibrate relative humidity transmitters at zero, 50, and 100 percent of span.
 9. Pressure: Calibrate pressure transmitters at zero, 50, and 100 percent of span.
 10. Temperature: Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

11. Dampers: Stroke and adjust control dampers following the recommended procedure from manufacturer, such that damper is 100 percent open and closed.
12. Replace out-of-tolerance instruments failing the test.
13. Provide diagnostic and test instruments for calibration and adjustment.

2.23 HARDWARE

A. Screws:

1. For Galvanized-Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
2. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
3. Provide protective covers on exposed screws to prevent personnel injury.

B. Bolts, Nuts, and Washers:

1. For Joining Galvanized and Painted Carbon-Steel Materials: Hex-head, high-strength, 300 series stainless steel.
2. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.
3. Use washers and lock washers at each bolted connection.
4. Select bolt size and spacing sufficient for load and application.

2.24 WELDING

A. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.

1. Use welding materials with corrosion properties equal to material being welded.

B. Use welders that are certified to weld at least twice the thickness of the material to be welded. Certification shall be within six months of work being performed.

C. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds, and tack welds are permitted only in specific applications indicated.

D. Use welders and welding procedures complying with the following:

1. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
2. Structural Aluminum: AWS D1.2/D1.2M.
3. Structural Carbon Steel: AWS D1.1/D1.1M.
4. Structural Stainless Steel: AWS D1.6/D1.6M.
5. Sheetmetal: AWS D9.1/D9.1M.

2.25 CLEANLINESS REQUIREMENTS

A. General:

1. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.
2. Owner Cleanliness Inspection: Air-handling unit(s) cleanliness is subject to Owner cleanliness inspection and must pass a white glove test before packaging for shipment.

B. During Manufacturing:

1. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
2. Protect casing materials from contamination during manufacturing and assembly.
3. Use sealing materials that do not outgas.
4. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.

C. After Manufacturing:

1. Before shipment, after unit is completely assembled, clean unit inside and out.
 - a. Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - b. Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - c. Wipe down all surfaces, inside and out, with a residue-free cleaning agent.
2. Protect unit to maintain cleanliness.

D. Shipping:

1. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
2. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.

E. On-Site Storage:

1. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
2. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended by manufacturer) without compromising unit cleanliness.

2.26 ACCESSORIES

A. Tool Kit:

1. Manufacturer shall assemble a tool kit specially designed for use in servicing air-handling units furnished.
2. Include only special tools required to service air-handling unit components not readily available for purchase by Owner service personnel in performing routine maintenance.
3. Place tools in a lockable case with hinged cover.
4. Mark case cover with large and permanent text to indicate special purpose of tool kit, such as "Air-Handling Unit Tool Kit." Text size shall be at least 1 inch (25 mm) high.
5. Provide a list of each tool furnished and permanently attach the list to underside of case cover. Text size shall be at least 1 inch (25 mm) high.

2.27 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."

2. AHRI 261 (SI): Air-handling unit sound ratings shall be in accordance with AHRI 261 (SI), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
 3. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI and labeled in accordance with AHRI.
- B. AMCA Compliance:
1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
 2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans" and shall bear the AMCA-certified FEG seal.
 3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating" and shall bear the AMCA-certified air ratings seal.
 4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
 5. AMCA 301 Certification: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data" and shall bear the AMCA-certified sound ratings seal.
 6. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating" and shall bear the AMCA-certified air ratings seal.
- C. NFPA Compliance:
1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
 2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.
- D. UL Compliance:
1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."
 2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."
- 2.28 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS
- A. Witness of Testing: Allow Commissioning Agent access to place where air-handling units are being tested for witness testing.
1. Submit written notification at least 30 days in advance of testing.
 2. Schedule testing at mutually agreeable dates and times.
- B. Casing Leakage Test:
1. Perform a leak test for each assembled air-handling unit.
 2. Follow testing procedures in accordance with ASHRAE 111.
 3. Perform leak test before shipping first air-handling unit.

4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
 5. Prepare test reports in accordance with ASHRAE 111.
 6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.
- C. Functional Run Test:
1. Run test each unit before shipment.
 2. Test and balance fans to comply with vibration requirements indicated.
 3. Energize each electrical device to ensure that it is operational.
 - a. Take meter readings for volts, amperes, and kVAr on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVAr on each single-phase power connection to field power.
 4. Exercise each damper to ensure proper operation.
 5. Exercise each access door to ensure proper fit.
 6. Exercise each valve to ensure proper operation.
 7. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.
- D. Fan Vibration Test:
1. Perform a fan vibration test for each assembled air-handling unit.
 2. Energize each fan within the air-handling unit after air-handling unit final assembly and perform a vibration analysis with fan operating at design speed and at all speeds throughout the range from design to minimum speed.
 3. Three vibration measurements shall be taken for each bearing in horizontal, vertical, and axial directions. Vibration measurements shall be recorded and consist of vibration amplitude verses frequency with filter-in.
 4. Fan bearing measurement points shall be marked or scribed on bearings for permanent record.
 5. Test results shall indicate that units comply with vibration requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
 6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.
- E. Airflow Capacity Performance Test:
1. Perform an airflow capacity performance test for each assembled air-handling unit.
 2. Operating conditions shall be verified by test in accordance with AMCA 210.

3. Test results shall indicate that units comply with design airflow requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 2. Piping systems to verify actual sizes, types, and locations of connections.
 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 4. Electrical services and controls to verify actual sizes, types, and locations of connections.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on concrete equipment bases.
 1. Units Mounted on Concrete Bases:
 - a. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 - b. Level air-handling unit bases using aluminum or stainless steel shims compatible with air-handling unit base material.
 - c. Fill voids between air-handling unit bases and concrete bases using high-strength non-shrink grout.
 - d. Continuously seal between concrete bases and perimeter of air-handling unit bases with nonhardening sealant.
- B. Equipment Clearances and Access:
 1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 2. Provide clearance and access required by governing codes and NFPA 70.
 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
 - 1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 - 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.
 - 1. Open access doors only during periods authorized work inside air-handling units is required.
 - 2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
 - 3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 23 3113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 23 3300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.
- C. Connect piping to air-handling units with flexible connectors.
- D. Drain Pan Piping: Comply with applicable requirements in Section 23 2113 "Hydronic Piping."
 - 1. Make connections to air-handling unit connections with flanges or unions.
 - 2. Extend dedicated drain piping from each air-handling unit connection to nearest equipment or floor drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 - 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 - 4. Install threaded cleanouts at changes in direction.
 - 5. Secure drain piping to structure.

- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Chilled-and Hot-Water Coil Piping: Comply with applicable requirements in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties."
 - 1. Comply with requirements indicated on Drawings.
 - 2. Make connections to coils with a flange or union.
 - 3. Connect to each coil inlet with shutoff valve, test plug, pressure gauge and thermometer.
 - 4. Connect to each coil outlet with balancing valve, test plug, pressure gauge and thermometer flow meter and shutoff valve.
 - 5. Connect each coil drain connection with a drain valve, which is full size of drain connection. Connect drain pipe to drain valve with union, and extend drain pipe to terminate over floor drain.
 - 6. Connect each coil vent connection with automatic vent, which is full size of vent connection.
- G. Steam Humidifier Piping: Comply with applicable requirements in Section 23 2213 "Steam and Condensate Heating Piping" and Section 23 2216 "Steam and Condensate Heating Piping Specialties." Install gate valve and inlet strainer at supply connection of steam humidifiers and steam trap assemblies to condensate return connection.

3.6 ELECTRICAL CONNECTIONS

- A. Install field power to each air-handling unit electrical power connection. Coordinate with air-handling unit manufacturer and installers.
- B. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 26 0523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that face-and-bypass dampers provide full face flow.
 - 7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - 8. Comb coil fins for parallel orientation.
 - 9. Verify that proper thermal-overload protection is installed for electric heaters.
 - 10. Install new, clean filters.
 - 11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
 - 2. Measure and record motor electrical values for voltage and amperage.
 - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt, and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning, submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units with absolute filters must pass a white glove test.

3.11 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. After field piping connections are complete, test hydronic coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Field-Assembly Supervision: Instruct Installer and supervise field installation of first air-handling unit(s) shipped in multiple pieces for field assembly.
 - 4. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Field Casing Leakage Test:
 - 1. Perform leak testing of air-handling units that include field assembly of multiple sections. Air-handling units that are shipped and installed as a single piece do not require field testing.
 - 2. Leak test one air-handling unit(s) of each unique size and arrangement randomly selected by COTR.
 - 3. Follow procedures complying with ASHRAE 111.

4. Assembled air-handling units shall satisfy leakage criteria indicated. Modify air-handling units that fail to satisfy criteria and retest. For every air-handling unit that fails test, another air-handling unit shall be tested until all air-handling units tested pass leakage criteria on first attempt.
5. Submit a test report for each test indicating test equipment, procedures, results, date and time, and full name of personnel performing tests and witnesses.
6. Test report shall be in accordance with ASHRAE 111.
7. Witness Testing:
 - a. Provide written notification at least 30 business days in advance of testing.
 - b. Testing shall be conducted in presence of testing and balancing agent.
 - c. Other parties such as Architect, Commissioning Agent, and Owner shall be invited to witness testing with attendance being optional.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.

1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.
 - d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage, and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least two years after the warranty indicated expires.
3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.

B. Filtration during Temporary Use:

1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.
2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 8 in accordance with ASHRAE 52.2.

3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting, and balancing.

- C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
 1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 3. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 4. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 5. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 6. Drain Pans: Cleaning, removal, and replacement.
 7. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.
 8. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
 9. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
 10. Humidifiers: Cleaning, operation, service, removal and replacement, and spare parts.
 11. UV-C Lamp Systems: Cleaning, operation, service, removal and replacement, and spare parts.
 12. Lights, Receptacles, and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
- C. Instructor:
 1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
 2. Instructor's credentials shall be submitted for review by Owner before scheduling training.
 3. Instructor(s) primary job responsibility shall be Owner training.
 4. Instructor(s) shall have not less than three years of training experience with air-handling unit manufacturer and past training experience on at least three projects of comparable size and complexity.
- D. Schedule and Duration:
 1. Schedule training with Owner at least 20 business days before first training session.

2. Training shall occur before Owner occupancy.
 3. Training shall be held at mutually agreed date and time during normal business hours.
 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for a one -hour lunch period and 15 -minute break after every two hours of training.
 5. Perform not less than eight hours of training.
- E. Location: Owner to provide a suitable on-site location to host classroom training.
- F. Training Attendees: Assume three people.
- G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.
- H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.
- I. Training Materials: Provide training materials in electronic format to each attendee.
1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
- J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- K. Written Acceptance: Obtain Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION

SECTION 23 8216.11 - HYDRONIC AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Hydronic air coils.
 - 2. Integral face-and-bypass hot-water coils.
- B. Related Requirements:
 - 1. Section 23 8216.12 "Steam Air Coils" for air coils using steam as the heating medium.
 - 2. Section 23 8216.13 "Refrigerant Air Coils" for air coils using refrigerants as the medium.
 - 3. Section 23 8216.14 "Electric-Resistance Air Coils" for electric air coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

- A. Altitude above Mean Sea Level: <Insert feet (m)>.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE 62.1 Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment," and Section 7, "Construction and Startup."

- B. Performance Ratings: Tested and rated in accordance with AHRI 410 and ASHRAE 33.
- C. Minimum Working-Pressure/Temperature Ratings: [200 psig (1380 kPa)/300 deg F (149 deg C)] **<Insert value and temperature>**.
- D. Select cooling coils for no moisture carryover at design conditions. Provide moisture eliminators on discharge face of cooling coil if necessary to eliminate moisture carryover.
- E. Hot-Water Coil Capacities and Characteristics:
1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
 2. Number of Rows: **<Insert number>**.
 3. Coating: **<Insert manufacturer; product>**.
 4. Serpentine: **[Half] [Full]**.
 5. Integral Face-and-Bypass Coil: **[Yes] [No]**.
 6. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Entering Temperature: **<Insert deg F (deg C)>**.
 - f. Leaving Temperature: **<Insert deg F (deg C)>**.
 7. Water Side:
 - a. Flow Rate: **<Insert gpm (L/s)>**.
 - b. Tube Velocity: **<Insert fpm (m/s)>**.
 - c. Glycol Type: **[Ethylene] [Propylene]**.
 - d. Aqueous Glycol Solution Concentration: **[None] <Insert percentage> [by weight] [by volume]**.
 - e. Pressure Drop: **<Insert feet (kPa)>**.
 - f. Entering Temperature: **<Insert deg F (deg C)>**.
 - g. Leaving Temperature: **<Insert deg F (deg C)>**.
- F. Chilled-Water Coil Capacities and Characteristics:
1. Coil Face Dimensions:
 - a. Finned Length: **<Insert inches (mm)>**.
 - b. Finned Width: **<Insert inches (mm)>**.
 2. Number of Rows: **<Insert number>**.
 3. Coating: **<Insert manufacturer; product>**.
 4. Serpentine: **[Half] [Full] [Double]**.
 5. Air Side:
 - a. Flow Rate: **<Insert cfm (L/s)>**.
 - b. Finned Area Face Velocity: **<Insert fpm (m/s)>**.
 - c. Static Pressure Drop: **<Insert inches wg (Pa)>**.
 - d. Total Capacity: **<Insert Btu/h (kW)>**.
 - e. Sensible Capacity: **<Insert Btu/h (kW)>**.
 - f. Entering Dry-Bulb Temperature: **<Insert deg F (deg C)>**.
 - g. Entering Wet-Bulb Temperature: **<Insert deg F (deg C)>**.
 - h. Leaving Dry-Bulb Temperature: **<Insert deg F (deg C)>**.

- i. Leaving Wet-Bulb Temperature: <Insert deg F (deg C)>.
6. Water Side:
 - a. Flow Rate: <Insert gpm (L/s)>.
 - b. Tube Velocity: <Insert fpm (m/s)>.
 - c. Glycol Type: [Ethylene] [Propylene].
 - d. Aqueous Glycol Solution Concentration: [None] <Insert percentage> [by weight] [by volume].
 - e. Pressure Drop: <Insert feet (Pa)>.
 - f. Entering Temperature: <Insert deg F (deg C)>.
 - g. Leaving Temperature: <Insert deg F (deg C)>.

2.2 HYDRONIC AIR COILS

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 1. Aerofin.
 2. Carrier Corporation; a unit of United Technologies Corp.
 3. Coil Company, LLC.
 4. Colmac Coil Manufacturing, Inc.
 5. Greenheck Fan Corporation.
 6. Modine Commercial and Industrial Solutions.
 7. RAE Coils; a division of RAE Corporation.
 8. Super Radiator Coils.
 9. Trane.
 10. USA Coil & Air.
 11. Insert manufacturer's name.
- B. Source Limitations: Obtain hydronic coils from single source from single manufacturer.
- C. Description: Coils constructed of staggered tubes mechanically expanded into continuous collars that are die-formed into the coil fins; self-venting; counterflow design of air to fluid.
- D. Tubes:
 1. Material: Copper aluminum carbon steel 90/10 cupronickel alloy stainless steel Insert material.
 2. Nominal Diameter: Minimum 1/2 inch (13 mm) 5/8 inch (16 mm) Insert nominal diameter before expanding, selected to provide performance indicated.
 3. Nominal Wall Thickness: As required by performance, minimum 0.020 inch (0.508 mm) 0.025 inch (0.635 mm) 0.035 inch (0.889 mm) 0.049 inch (1.245 mm) Insert dimension thick.
 4. Return Bends: 180-degree bends; material[, wall thickness,] and nominal diameter to match tubes.
 5. Fluid Velocity at Design Flow Rate:
 - a. Maximum: 6 fps (1.8 m/s) Insert velocity.
 - b. Minimum: 3 fps (0.9 ms) Insert velocity.
 6. Features: Cleanable Individually drainable.
- E. Fins:
 1. Type: Plate.
 2. Materials:
 - a. Aluminum: 0.0060 inch (0.15 mm) Insert dimension thick.

- b. <Insert fin material and thickness>.
 3. Spacing: Maximum 12 fins per inch (2.1 mm) Insert maximum fin spacing.
 4. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 5. Configuration: Flat-face fins Wave-, corrugated-, or waffle-face fins Fin type as required by performance requirements Insert fin type.
 6. Fin and Tube Joint: Mechanical bond silver brazed.
- F. Headers:
 1. Material: Carbon steel Copper Insert material.
 2. Tube-to-Header Connections: Tube-to-header holes to intrude inward, so landed surface area is 3 times the core tube thickness, to provide enhanced-header-to-tube joint integrity. Evenly extend tubes within the ID of the header no more than 0.12 inch (3 mm).
 3. Header Top and Bottom Caps: End caps to be die-formed and installed on the ID of header, such that the landed surface area is 3 times the header wall thickness.
 4. Drains: Include low point of supply supply and return header with a NPS 1/2 (DN 13) Insert pipe size drain connection.
 5. Vents: Include high point of return supply and return header with a NPS 1/2 (DN 13) Insert pipe size vent connection.
 6. Supply and Return Connections: Copper Carbon steel Red brass pipe, threaded flanged, same end opposite ends of coil.
 7. Protect opening of supply, return, vent, and drain connections with a threaded cap to prevent entry of dirt into coil.
 8. Fluid Velocity at Design Flow Rate: Maximum of 6 fps (1.8 m/s) Insert velocity.
- G. Casings and Tube Sheets:
 1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch (13 mm) Insert dimension beyond face of fins on both entering and leaving sides.
 2. Materials:
 - a. Stainless steel, Type 304 Insert type, No. 2D finish, ASTM A240/A240M.
- H. Top and Bottom Casings:
 1. Flange face minimum of 1-1/2 inches (68 mm) Insert dimension; double-flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch (13 mm) Insert dimension.
 2. Thickness:
 - a. Coils with Fin Length of Up to 72 Inches (1800 mm) Insert dimension: Minimum of 16 gauge (1.6 mm) 14 gauge (2.0 mm) 12 gauge (2.8 mm) thick.
 - b. Coils with Fin Length Exceeding 72 Inches (1800 mm) Insert dimension: Minimum of 16 gauge (1.6 mm) 14 gauge (2.0 mm) 12 gauge (2.8 mm) thick.
- I. End Tube Sheets:
 1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 2. Flange face minimum of 1-1/2 inches (68 mm) Insert dimension.
 3. Thickness: Minimum of 16 gauge (1.6 mm) 14 gauge (2.0 mm) 12 gauge (2.8 mm) thick.
- J. Intermediate Tube Sheets:
 1. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.

2. Space intermediate tube sheets a maximum of [48 inches (1200 mm)] **<Insert dimension>** o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 3. Flange face minimum of 1/2 inch (13 mm) **Insert dimension**.
 4. Thickness: Minimum of 16 gauge (1.6 mm) **Insert thickness thick**.
- K. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.
- L. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 304 Type 316 stainless steel.
- M. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
 5. Coil identification (indicated on Drawings).
 6. Coil fin length.
 7. Coil fin height.
 8. Coil weight with fluid/without fluid.
 9. Coil casing material and thickness.
 10. Coil fin material and thickness.
 11. Coil tube material and thickness.
 12. Coil header material and thickness.
 13. **<Insert requirements>**.
- N. Comply with Section 23 0546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.
- O. Coating: None Corrosion resistant **Insert manufacturer; product name**.
- 2.3 HOT-WATER HEATING COILS WITH INTEGRAL FACE-AND-BYPASS DAMPERS
- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
1. DRS Marlo Coil; part of DRS Technologies, Inc.
 2. Wing, L. J.; A Mestek Company.
 3. **Insert manufacturer's name**.
- B. Source Limitations: Obtain integral face-and-bypass coils from single source from single manufacturer.
- C. Description: Hydronic coil with horizontal vertical tube arrangement[**as indicated on Drawings**] with integral face-and-bypass dampers and controls installed to control modulating dampers, to achieve discharge air temperature set point. Design includes alternating arrangement of active coil segments and dampers.
- D. Performance:

1. Each coil capable of maintaining constant discharge air temperature, regardless of variations in entering-air temperature with constant water flow through coil.
 2. Portioning of air across and around heating element to result in uniform temperature within 5 deg F (3 deg C) of average temperature when measured anywhere across a vertical plane located [24 inches (600 mm)] [36 inches (900 mm)] downstream of leaving face of coil.
- E. Casing: Galvanized steel stainless steel, minimum of 16 gauge (1.6 mm) thick.
- F. Fins: Rectangular shape, constructed of minimum 0.010-inch- (0.25-mm-) Insert dimension thick aluminum, with spacing of not closer than 12 fins per inch (2.1 mm) Insert fin spacing.
- G. Headers: Carbon steel copper, selected by manufacturer for flow, pressure, and temperature encountered; drain connections at low points, vent connections at high points, and supply and return connections located on discharge face of coil.
1. Insulation: Insulate headers with mineral-fiber insulation covered by a metal jacket.
 2. Supply and Return Connections:
 - a. Terminate ends with MNPT.
 - b. Connections NPS 2-1/2 (DN 65) Insert pipe size and larger shall have thread-on flanges. Select flange class, Class 150 or Class 300, for system pressure and temperature encountered.
- H. Tubes:
1. Materials: Copper 90/10 cupronickel carbon steel.
 2. Nominal Diameter: 5/8 inch (16 mm).
 3. Nominal Wall Thickness: As required by performance, minimum of 0.035 inch (0.9 mm) 0.049 inch (1.2 mm) thick.
- I. Dampers: Clamshell design arranged to modulate airflow across or around individual heating elements.
1. Material: Galvanized steel stainless steel, minimum of 16 gauge (1.6 mm) thick.
 2. Actuator: Face or side mounted; electric motor for proportional control, failing in last position.
- J. Brazing: High-temperature brazing alloy with not less than 5 percent silver when brazing like non-ferrous materials together; high-temperature brazing alloy with more than 30 percent silver when brazing ferrous to non-ferrous materials.
- K. Hardware: Use hex-head bolts, nuts, and washers constructed of zinc-plated carbon steel stainless steel.
- L. Nameplate: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
 5. Coil identification (indicated on Drawings).
 6. <Insert requirements>.

M. Comply with Section 23 0546 "Coatings for HVAC" for corrosion-resistant coating. See Drawings for coils requiring a corrosion-resistant coating.

N. Coating: None Corrosion resistant Insert manufacturer; product name.

2.4 MATERIALS

A. Aluminum: ASTM B209 (ASTM B209M).

B. Copper Tube: ASTM B75/ASTM 75M annealed temper or ASTM B280 drawn temper.

C. Copper Sheet: ASTM B152.

D. 90/10 Cupronickel Alloy: ASTM B122/ASTM B122M.

E. Steel:

1. Pipe Connections: ASTM A53/A53M.

F. Corrosion-Resistant Coating: Where indicated on Drawings, coat coils with a corrosion-resistant coating capable of withstanding a [3000] <Insert time>-hour salt-spray test in accordance with ASTM B117.

1. Standards:

a. ASTM B117 for salt spray.

b. ASTM D2794 for minimum impact resistance of 100 in. lb (11.3 N m).

c. ASTM D3359 for cross-hatch adhesion of 5B.

2. Application: [Immersion] [Spray].

3. Thickness: [1 mil (0.025 mm)] <Insert value>.

4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.5 SOURCE QUALITY CONTROL

A. Hydronic Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than [300-psig (2070-kPa)] <Insert pressure> internal pressure.

B. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.
- B. Install coils in metal ducts and casings constructed in accordance with SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Install [**galvanized-steel**] [**stainless steel**] drain pan under each cooling coil.
 - 1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
 - 2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
 - 3. Extend drain pan upstream and downstream from coil face.
 - 4. Extend drain pan under coil headers and exposed supply piping.
- D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
- E. Straighten bent fins on air coils.
- F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to coils to allow service and maintenance.
- C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 23 0923.11 "Control Valves," and other piping specialties are specified in Section 23 2116 "Hydronic Piping Specialties."

END OF SECTION

SECTION 23 8219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ductless fan coil units.
 - 2. Ducted fan coil units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
 - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include diagrams for power, signal, and control wiring.
- D. Samples for Initial Selection: For units with factory-applied color finishes.
- E. Samples for Verification: For each type of fan coil unit indicated.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which fan coil units will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Sprinklers.
 - c. Access panels.
 - d. .
 - 6. Perimeter moldings.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fan coil units to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fan Coil Unit Filters: Furnish two spare filters for each filter installed.
 - 2. Fan Belts: Furnish one spare fan belts for each unit installed.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 COORDINATION

- A. Coordinate layout and installation of fan coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period: Five years from date of Substantial Completion.
 - 3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Factory-packaged and -tested units rated according to AHRI 440, ASHRAE 33, and UL 1995.

2.2 DUCTLESS FAN COIL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
 2. Daikin Applied.
 3. ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America.
 4. Titus; brand of Johnson Controls International plc, Global Products.
 5. Trane Inc.
 6. YORK; brand of Johnson Controls International plc, Building Solutions North America.
- B. Coil Section Insulation:
1. 1/2-inch- (13-mm-) thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 2. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Drain Pans: Main and Auxiliary Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.
- D. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- E. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
1. MERV Rating: 6 Insert number when tested according to ASHRAE 52.2.
 2. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.
- F. Hydronic Coils: Copper tube with corrosion-resistant coating, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.
- G. Corrosion-Resistant Coating: Coat coils with a corrosion-resistant coating capable of withstanding a 3,000 -hour salt-spray test according to ASTM B117.
1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
 - c. ASTM D3359 for cross hatch adhesion of 5B.
 2. Application: Immersion.
 3. Thickness: 1 mil.
 4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.
- H. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 0500 "Common Work Results for HVAC."
 3. Wiring Termination: Connect motor to chassis wiring with plug connection.
- I. Factory, Hydronic Piping Package: ASTM B88, Type L (ASTM B88M, Type B) ASTM B88, Type M (ASTM B88M Type C) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Two-way, modulating control valve for chilled-water coil.
 2. Two-way, modulating control valve for hot-water heating coil.
 3. Hose Kits: Minimum 400-psig (2758-kPa) working pressure and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - a. Length: 24 inches (600 mm) Insert dimension.
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 4. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
 5. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 6. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 7. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 3/4 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
 8. Wrought-Copper Unions: ASME B16.22.
- J. Control devices and operational sequences are specified in Section 23 0923 "Direct Digital Control (DDC) System for HVAC" and Section 23 0993.11 "Sequence of Operations for HVAC DDC."
- K. Basic Unit Controls:
1. Control voltage transformer.
- L. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.
 2. Interface relay to provide indication of fault at the central workstation.
 3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including supply- and room-air temperature and humidity.
 - d. Occupied and unoccupied schedules.
- M. Electrical Connection: Factory wire motors and controls for a single electrical connection.

2.3 DUCTED FAN COIL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Global Corporation.
 2. Daikin Applied.
 3. Titus; brand of Johnson Controls International plc, Global Products.
 4. Trane Inc.
 5. YORK; brand of Johnson Controls International plc, Building Solutions North America.
- B. Fan Coil Unit Configurations: Row split.
1. Number of Cooling Coils: One with two-pipe system.
- C. Coil Section Insulation:
1. 1/2-inch- (13-mm-) thick, coated glass fiber complying with ASTM C1071 and attached with adhesive complying with ASTM C916.
 2. Insulate coil section according to Section 23 0716 "HVAC Equipment Insulation."
 3. Surface-Burning Characteristics: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E84 by a qualified testing agency.
 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.
- E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panel. Floor-mounting units shall have leveling screws.
- F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille.
- G. Filters: Minimum arrestance and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2 and all addendums.
- H. MERV Rating: 6 when tested according to ASHRAE 52.2.
1. Pleated Cotton-Polyester Media: 90 percent arrestance and MERV 7.
- I. Hydronic Coils: Copper tube with corrosion-resistant coating, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.
- J. Corrosion-Resistant Coating: Coat coils and fan guards with a corrosion-resistant coating capable of withstanding a [3,000] <Insert time>-hour salt-spray test according to ASTM B117.
1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m)
 - c. ASTM D3359 for cross hatch adhesion of 5B.

2. Application: Immersion.
 3. Thickness: 1 mil.
 4. Gloss: Minimum gloss of 50 gloss units on a single angle 60 degree meter.
- K. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
1. Motors: Comply with requirements in Section 23 0500 "Common Work Results for HVAC."
- L. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
1. Motors: Comply with requirements in Section 23 0500 "Common Work Results for HVAC."
- M. Factory, Hydronic Piping Package: ASTM B88, Type L (ASTM B88M, Type B) copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Two-way, modulating control valve for chilled-water coil.
 2. Two-way, modulating control valve for heating coil.
 3. Hose Kits: Minimum 400-psig (2758-kPa) working pressure and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.
 - a. Length: 24 inches (600 mm).
 - b. Minimum Diameter: Equal to fan coil unit connection size.
 4. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
 5. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and a memory stop to retain set position.
 6. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
 7. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 3/4 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
 8. Wrought-Copper Unions: ASME B16.22.
- N. Remote condensing units are specified in Section 23 6200 "Packaged Compressor and Condenser Units."
- O. Control devices and operational sequence are specified in Section 23 0548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- P. Basic Unit Controls:
1. Control voltage transformer.
- Q. Interface with DDC System for HVAC Requirements:
1. Interface relay for scheduled operation.

2. Interface relay to provide indication of fault at the central workstation.
3. Provide BACnet interface for central DDC system for HVAC workstation for the following functions:
 - a. Adjust set points.
 - b. Fan coil unit start, stop, and operating status.
 - c. Data inquiry, including supply- and room-air temperature and humidity.
 - d. Occupied and unoccupied schedules.

R. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, with Installer present, to receive fan coil units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before fan coil unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF FAN COIL UNITS

- A. Install fan coil units level and plumb.
- B. Install fan coil units to comply with NFPA 90A.
- C. Suspend fan coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 23 0548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
- D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above finished floor.
- E. Install new filters in each fan coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 1. Install piping adjacent to machine to allow service and maintenance.
 2. Connect piping to fan coil unit factory hydronic piping package. Install piping package if shipped loose.
 3. Connect condensate drain to indirect waste.
 - a. Install condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Connect supply-air and return-air ducts to fan coil units with flexible duct connectors specified in Section 23 3300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

- C. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fan coil units.

END OF SECTION

SECTION 23 8233 - CONVECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes convectors.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive convectors for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for connections to verify actual locations before installation of convector.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install convectors level and plumb.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in [Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties."] [Section 23 2213 "Steam and Condensate Heating Piping" and Section 23 2216 "Steam and Condensate Heating Piping Specialties."] Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water convectors and components to piping according to Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Connect steam convectors and components to piping according to Section 23 2213 "Steam and Condensate Heating Piping" and Section 23 2216 "Steam and Condensate Heating Piping Specialties."
 - 1. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
- D. Install control valves as required by Section 23 0923.11 "Control Valves."
- E. Install piping adjacent to convectors to allow service and maintenance.

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 8239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Propeller unit heaters with hot-water, steam, or electric-resistance heating coils.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. PTFE: Polytetrafluoroethylene plastic.
- C. TFE: Tetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - 2. Ventilation: Product Data for ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include location and size of each field connection.
 - 4. Include details of anchorages and attachments to structure and to supported equipment.
 - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 6. Indicate location and arrangement of piping valves and specialties.
 - 7. Indicate location and arrangement of integral controls.
 - 8. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which propeller unit heaters will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:

- a. Lighting fixtures.
- b. Air outlets and inlets.
- c. Speakers.
- d. Sprinklers.
- e. Access panels.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Airtherm; a Mestek company.
 - 2. CCI Thermal Technologies, Inc.
 - 3. Engineered Air.
 - 4. Rosemex Products.
 - 5. Trane.
- B. Heaters: Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with UL 2021.
- E. Comply with UL 823.

2.2 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.3 HOUSINGS

- A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
- B. Airstream Surfaces: Surfaces in contact with the airstream comply with requirements in ASHRAE 62.1.

- C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.4 COILS

- A. General Coil Requirements: Test and rate hot-water propeller unit-heater coils in accordance with ASHRAE 33.
- B. Hot-Water Coil:
 - 1. Fluid : 30% Propylene Glycol.
 - 2. Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.

2.5 FAN AND MOTOR

- A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 23 0500 "Common Work Results for HVAC."

2.6 CONTROLS

- A. Control Devices:
 - 1. Wall-mounted, variable fan-speed switch.
 - 2. Wall-mounted thermostat.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF PROPELLER UNIT HEATERS

- A. Install propeller unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 23 0548.13 "Vibration Controls for HVAC."

- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- E. Locate all controls, valves, vents and access accessories outside animal enclosure.

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
 - 1. Section 23 2113 "Hydronic Piping."
 - 2. Section 23 2116 "Hydronic Piping Specialties."
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to propeller unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of propeller unit heater. Hydronic specialties are specified in Section 23 2113 "Hydronic Piping" and Section 23 2116 "Hydronic Piping Specialties."
- F. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of propeller unit heater. Steam specialties are specified in Section 23 2216 "Steam and Condensate Piping Specialties."
- G. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- H. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION

FOR REFERENCE ONLY

SECTION 23 8316 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes radiant-heating piping, including pipes, fittings, and piping specialties.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. PEX: Crosslinked polyethylene.
- C. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.
- D. PTFE: Polytetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
- B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
 - 1. Shop Drawing Scale: 1/4 inch = 1 foot (1:50).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which radiant-heating piping will be attached.
 - 3. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. <Insert item>.
 - 4. Perimeter moldings.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. IPEX Inc.
 - 2. Slant/Fin Corporation.
 - 3. Uponor.
 - 4. Viega.
 - 5. Watts Radiant, inc.; a Watts Water Technologies company.
 - 6. Zurn Industries, LLC; Zurn Pex, Inc.
- B. Pipe Material: PEX plastic according to ASTM F 876.
- C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
- D. Fittings: ASTM F 1807, metal insert and copper crimp rings.
- E. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

2.2 PEX/AL/PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. IPEX Inc.
 - 2. Uponor.
 - 3. Viega.
- B. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.
- C. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
- D. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
- E. Flame-Spread and Smoke-Developed Indices: 25 and 50 or less, respectively, tested according to ASTM E 84.
- F. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

2.3 DISTRIBUTION MANIFOLDS

- A. Manifold: Minimum NPS 1 (DN 25), stainless steel.
- B. Main Shutoff Valves:
 - 1. Factory installed on supply and return connections.

2. Three-piece body.
 3. Body: Brass or bronze.
 4. Ball: Chrome-plated bronze.
 5. Seals: PTFE.
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 225 deg F (107 deg C).
- C. Manual Air Vents:
1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Key furnished with valve, or screwdriver bit.
 4. Inlet Connection: NPS 1/2 (DN 15).
 5. Discharge Connection: NPS 1/8 (DN 6).
 6. CWP Rating: 150 psig (1035 kPa).
 7. Maximum Operating Temperature: 225 deg F (107 deg C).
- D. Balancing Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 2. Ball or Plug: Brass or stainless steel.
 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 4. Seat: PTFE.
 5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
 6. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
 8. CWP Rating: Minimum 125 psig (860 kPa).
 9. Maximum Operating Temperature: 250 deg F (121 deg C).
- E. Zone Control Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 2. Ball or Plug: Brass or stainless steel.
 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 4. Seat: PTFE.
 5. Actuator: Replaceable electric motor.
 6. CWP Rating: Minimum 125 psig (860 kPa).
 7. Maximum Operating Temperature: 250 deg F (121 deg C).
- F. Thermometers:
1. Mount on supply and return connections.
 2. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
 3. Element: Bourdon tube or other type of pressure element.
 4. Movement: Mechanical, connecting element and pointer.
 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 6. Pointer: Black metal.
 7. Window: Plastic.
 8. Connector: Rigid, back type.
 9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
 10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

- G. Mounting Brackets: Copper, or plastic- or copper-clad steel, where in contact with manifold.

2.4 PIPING SPECIALTIES

A. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch (3 mm).
3. Tensile Strength: 20 lb (9 kg), minimum.
4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

B. Floor Mounting Staples:

1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

C. Floor Mounting Clamps:

1. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish and no sharp edges.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: 2-inch (50-mm) intervals.

E. Channeled Subfloor:

1. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, seven-layer, Douglas fir structural subfloor panels.
2. Particleboard manufactured to comply with Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
3. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.

F. Modular Interlocking Blocks:

1. Polypropylene snap-together blocks with grooves to support piping.
2. Galvanized sheet metal or aluminum emission plates.
3. Natural mineralboard cover panel.

G. Heat-Emission Plates:

1. Formed aluminum suitable for radiant-heating piping.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to maintain pressure fit on tubing.

2.5 CONTROLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Danfoss Inc.
2. Honeywell International Inc.

3. IPEX Inc.
4. Slant/Fin Corporation.
5. tekmar Control Systems, Ltd.
6. Uponor.
7. Viega.
8. Watts Radiant, inc.; a Watts Water Technologies company.
9. Zurn Industries, LLC; Zurn Pex, Inc.

B. Heated-Panel Thermostat:

1. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant-panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
 2. Ensure that surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Install the following types of radiant-heating piping for the applications described:
 1. Piping in Interior Reinforced-Concrete Floors: PEX.
 2. Piping in Level Fill Concrete Floors (Not Reinforced): PEX.

3.3 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.
- B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.
- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

- E. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Section 08 3113 "Access Doors and Frames."
- F. See Section 23 2113 "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
- G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 07 8413 "Penetration Firestopping."
- H. Piping in Interior Reinforced-Concrete Floors:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
 - 3. Maintain 2-inch (50-mm) minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
- I. Piping in Level Fill Concrete Floors (Not Reinforced):
 - 1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - 2. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
 - 3. Maintain 3/4-inch (19-mm) minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.
- J. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.
- K. After system balancing has been completed, mark balancing valves to permanently indicate final position.
- L. Perform the following adjustments before operating the system:
 - 1. Open valves to fully open position.
 - 2. Check operation of automatic valves.
 - 3. Set temperature controls so all zones call for full flow.
 - 4. Purge air from piping.
- M. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant-panel temperature and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F (16 deg C) supply-water temperature.

3.4 FIELD QUALITY CONTROL

- A. Prepare radiant-heating piping for testing as follows:
 1. Open all isolation valves and close bypass valves.
 2. Open and verify operation of zone control valves.
 3. Flush with clean water and clean strainers.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Protect hydronic piping system from damage during construction.

END OF SECTION

SECTION 23 8413 - HUMIDIFIERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following humidifiers:
 - 1. Self-contained.

1.2 DEFINITION

- A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.3 COORDINATION

- A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 SELF-CONTAINED HUMIDIFIERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong International, Inc.
 - 2. DRI-STEEM Humidifier Company.
 - 3. Carel USA, LLC.
 - 4. Carnes Co., Inc.
 - 5. Herrmidifier.
 - 6. Hygromatik; Spirax Sarco, Inc.
 - 7. Neptronic.
 - 8. Nortec Industries Inc.
- B. Electric-Resistance Heater Container: Cleanable, ASTM A 666, Type 316 stainless steel. Comply with UL 499.
- C. Electrode Cylinder: Replaceable plastic assembly with disposable ionic bed inserts. Comply with UL 499.
- D. Manifold: Stainless-steel tube with integral fan to discharge vapor directly into occupied space.
- E. Manifold: ASTM A 666, Type 316 stainless-steel tube extending across entire width of duct or plenum and equipped with mounting brackets on ends.
- F. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.

- G. Control Panel:
 - 1. Factory-wired disconnect switch.
 - 2. Liquid-crystal display.
 - 3. Programmable keyboard.
 - 4. Set-point adjustment.
 - 5. Warning signal indicating end of replaceable cylinder[or ionic bed insert] life.
 - 6. Low-voltage, control circuit.
 - 7. Diagnostic, maintenance, alarm, and status features.
 - 8. High-water float to prevent overfilling.
- H. Controls:
 - 1. Microprocessor-based control system for modulating or cycling control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
 - 2. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
 - 3. Field-adjustable timer to control drain cycle for flush duration and interval.
 - 4. Controls shall drain tanks if no demand for humidification for more than 72 hours.
 - 5. Float-type level controls.
- I. Accessories:
 - 1. Humidistat: [Wall] [Return-duct]-mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
 - 2. Duct-mounting, high-limit humidistat.
 - 3. Airflow switch for preventing humidifier operation without airflow.
 - 4. Condensate cooler.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.
- B. Seal humidifier manifold duct or plenum penetrations with flange.
- C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- D. Install stainless-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

E. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 1. Install piping adjacent to humidifiers to allow service and maintenance.
 2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
- B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
- C. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Section 01 7900 "Demonstration and Training."

END OF SECTION

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

- A. Product Schedule: Indicate type, use, location, and termination locations.

1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **testing agency**.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
- B. Standards:
 - 1. Products listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.
 - 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide"

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alpha Wire Company.
 - 2. American Bare Conductor.
 - 3. Belden Inc.
 - 4. Cerro Wire LLC.
 - 5. Encore Wire Corporation.
 - 6. General Cable Technologies Corporation.
 - 7. Okonite Company (The).
 - 8. Service Wire Co.
 - 9. Southwire Company.
 - 10. WESCO.
- C. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 and ASTM B 496 for stranded conductors.
- D. Conductor Insulation:

1. Refer to Part 3 for conductor insulation application. Comply with UL Standard appropriate for cable insulation.

2.2 MINERAL-INSULATED CABLE, TYPE MI

- A. Description: Solid copper conductors encased in compressed metal oxide with an outer metallic sheath, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. nVent Pyrotenax.
- C. Standards:
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 2. UL 2196 for fire resistance.
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper.
- E. Insulation: Compressed magnesium oxide, minimum 55 mils for 600 volt power and control cables; minimum 23 mils for 300 volt twisted pair cables.
- F. Sheath: Copper, continuous and seamless, liquid- and gas-tight.

2.3 TRAY CABLE, TYPE TC FOR VFD OUTPUT CIRCUITS

- A. Description: A factory assembly of insulated current-carrying conductors with or without an equipment grounding conductor in a nonmetallic jacket.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Alpha Wire Company
 2. Belden Inc.
 3. Encore Wire Corporation.
 4. General Cable Technologies Corporation.
 5. Okonite Company (The).
 6. Service Wire Co.
 7. Southwire Company.
 8. WESCO.
- C. Standards:
 1. RoHS compliant.
 2. Comply with UL 1277.
 3. Comply with ICEA S-95-658/NEMA WC 70 for Type TC cables used for power distribution.
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
- E. Ground Conductor: Three stranded bare copper ground wires.

- F. Conductor Insulation: Type XHHW-2 or RHW-2. Comply with UL 44.
- G. Shield: Copper tape shield with a minimum of 50% overlap.

2.4 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M Electrical Products.
 - 2. AFC Cable Systems; a part of Atkore International.
 - 3. Gardner Bender.
 - 4. Hubbell Power Systems, Inc.
 - 5. Ideal Industries, Inc.
 - 6. ILSCO.
 - 7. NSi Industries LLC.
 - 8. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 9. Service Wire Co.
 - 10. TE Connectivity Ltd.
 - 11. Thomas & Betts Corporation; A Member of the ABB Group.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Bronze or matching conductor material.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.
- D. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.
- E. Isolated Power System Secondary Conductor Type: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- F. Feeders: Type THHN/THWN-2 or XHHW-2, single conductors in raceway.
- G. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway .

- H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway .
- I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2 or XHHW-2, single conductors in raceway .
- J. Branch Circuits Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway .
- K. Feeders and Branch Circuits Installed on Rooftops: Type XHHW-2, single conductors in raceway.
- L. Emergency Power System Branch Circuits: Type THHN-2/THWN-2, single conductors in raceway.
- M. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- N. VFD Output Circuits: Type TC-ER cable with tape shield.
- O. Smithsonian Design Standard: The use of Metal Clad (MC) cable for power and lighting branch circuits will be reviewed with SI for specific project requirements. The basis of design will include branch circuits run in Electrical Metallic Tubing (EMT) conduit, with a 1.8m (6ft) maximum whip length from junction box to lighting fixture position. MC cable for overall branch circuit length is not permitted.
- P. Smithsonian Design Standard: Wet Locations: Type XHHW-2, single conductors in raceway.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."
- G. Install cable per manufacturer's recommendations.

3.3 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm).

3.4 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.5 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 07 8413 "Penetration Firestopping."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 0523 - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.1 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- C. RCDD: Registered Communications Distribution Designer.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 PERFORMANCE REQUIREMENTS

- A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - 1. Flame Travel Distance: 60 inches (1520 mm) or less.
 - 2. Peak Optical Smoke Density: 0.5 or less.
 - 3. Average Optical Smoke Density: 0.15 or less.
- B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Test cables on receipt at Project site.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1 and NFPA 70.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C Series of standards.
 - 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems."

3. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
4. Cables may not be spliced.
5. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Install lacing bars and distribution spools.
7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
9. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems" and Ch. 6, "Optical Fiber Structured Cabling Systems." Monitor cable pull tensions.
10. Support: Do not allow cables to lay on removable ceiling tiles.
11. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.

3.3 REMOVAL OF CONDUCTORS AND CABLES

- A. Remove abandoned conductors and cables. Abandoned conductors and cables are those installed that are not terminated at equipment and are not identified for future use with a tag.

3.4 GROUNDING

- A. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

END OF SECTION

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

- A. +Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Plans showing as-built, dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Ground rods.
 - 3) Ground rings.
 - 4) Grounding arrangements and connections for separately derived systems.
 - b. Instructions for periodic testing and inspection of grounding features at **test wells, ground rings and grounding connections for separately derived systems** based on **NETA MTS**.
 - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Burndy; Part of Hubbell Electrical Systems.
 2. ERICO International Corporation.
 3. Galvan Industries, Inc.; Electrical Products Division, LLC.
 4. ILSCO.
 5. O-Z/Gedney; a brand of Emerson Industrial Automation.
 6. Robbins Lightning, Inc.
 7. Siemens Power Transmission & Distribution, Inc.
 8. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
1. Solid Conductors: ASTM B 3.
 2. Stranded Conductors: ASTM B 8.
 3. Bonding Conductor: No. 6 AWG, minimum, stranded conductor.
 4. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart, unless otherwise indicated or specified. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.
- D. Lead Content: Less than 300 parts per million.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless **exothermic**-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.

- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy.
- I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- K. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with **zinc-plated** or **stainless-steel** bolts.
 - a. Material: **Die-cast zinc alloy**.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and **copper ground connector**.
- L. Lead Content: Less than 300 parts per million.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: **Copper-clad**; 5/8 by 96 inches (16 by 2400 mm).
- B. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with **nonhazardous electrolytic chemical salts**.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2. Backfill Material: Electrode manufacturer's recommended material.
- C. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, **No. 2/0 AWG** minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus:
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Ground separately-derived ac power system neutrals, including distribution transformers, to the grounding electrode system **[per NFPA 70][as indicated on Drawings]**.
- B. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.

- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- E. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- G. Metallic Fences: Comply with requirements of IEEE C2.
 - 1. Grounding Conductor: Bare[, tinned] copper, not less than [No. 8] <Insert number> AWG.
 - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 FENCE GROUNDING

- A. Fence Grounding: Install at maximum intervals of [1500 feet (450 m)] <Insert a lesser distance if grounding resistance is high> except as follows:
 - 1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [750 feet (225 m)] <Insert a lesser distance if grounding resistance is high>.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
- B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
- C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.

- D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
- C. Ground Rods: Drive rods until tops are 24 inches (600 mm) below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least **three** <Insert number> rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 0543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- F. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to **[each steel column] [indicated columns]**, extending around the perimeter of **building**.
1. Install tinned-copper conductor not less than **No. 2/0** AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than **No. 4** AWG.
1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
- K. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet (6.0 m) long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.
- L. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[**with the assistance of a factory-authorized service representative**].
- E. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal[, **at ground test wells**][, **and at individual ground rods**]. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- F. Grounding system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: [10] **<Insert value>** ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: [5] **<Insert value>** ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: [3] **<Insert value>** ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: [1] [3] **<Insert value>** ohm(s).
 - 5. Substations and Pad-Mounted Equipment: [5] **<Insert value>** ohms.
 - 6. Manhole Grounds: [10] **<Insert value>** ohms.
 - 7. **<Insert application and maximum ground-resistance value>** ohms.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

- I. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Steel slotted support systems.
 - 2. Aluminum slotted support systems.
 - 3. Nonmetallic slotted support systems.
 - 4. Conduit and cable support devices.
 - 5. Support for conductors in vertical conduit.
 - 6. Structural steel for fabricated supports and restraints.
 - 7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - 8. Fabricated metal equipment support assemblies.
- B. Related Requirements:
 - 1. Section 26 0548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.
 - f. Fasteners.
 - g. Anchors.
 - h. Saddles.
 - i. Brackets.
 - j. **<Insert product type>.**
 - 2. Include rated capacities and furnished specialties and accessories.
- B. Shop Drawings: [**Signed and sealed by a qualified professional engineer.**] For fabrication and installation details for electrical hangers and support systems.
 - 1. Hangers. Include product data for components.
 - 2. Slotted support systems.
 - 3. Equipment supports.
 - 4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For hangers and supports for electrical systems.
 - 1. Include design calculations and details of hangers.
 - 2. Include design calculations for seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Ductwork, piping, fittings, and supports.
 3. Structural members to which hangers and supports will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Projectors.
 - g. **<Insert item>**.
- B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to [AWS D1.1/D1.1M] [AWS D1.2/D1.2M].
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
1. AWS D1.1/D1.1M.
 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design hanger and support system.
- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to [ASCE/SEI 7] **<Insert requirement>**.
1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified[**and the supported equipment and systems will be fully operational after the seismic event**]."

2. Component Importance Factor: [1.5] [1.0].
3. <Insert requirements for Component Amplification Factor and Component Response Modification Factor>.

- C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame Rating: Class 1.
 2. Self-extinguishing according to ASTM D 635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.
 - c. ERICO International Corporation.
 - d. Flex-Strut Inc..
 - e. GS Metals Corp.
 - f. G-Strut.
 - g. Haydon Corporation.
 - h. Metal Ties Innovation.
 - i. Thomas & Betts Corporation; A Member of the ABB Group.
 - j. Unistrut; Part of Atkore International.
 - k. Wesanco, Inc.
 - l. Insert manufacturer's name.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel Plain steel Stainless steel, Type 304 Stainless steel, Type 316.
4. Channel Width: Selected for applicable load criteria 1-5/8 inches (41.25 mm) 1-1/4 inches (31.75 mm) 13/16 inches (20.64 mm) Insert dimension.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

- B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.

1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Cooper Industries, Inc..

- b. Flex-Strut Inc..
 - c. Haydon Corporation.
 - d. MKT Metal Manufacturing.
 - e. Thomas & Betts Corporation; A Member of the ABB Group.
 - f. Unistrut; Part of Atkore International.
 - g. Insert manufacturer's name.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Channel Material: 6063-T5 aluminum alloy.
 4. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 5. Channel Width: Selected for applicable load criteria 1-5/8 inches (41.25 mm) 1-1/4 inches (31.75 mm) 13/16 inches (20.64 mm) Insert dimension.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least one surface.
1. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.
 - c. Fabco Plastics Wholesale Limited.
 - d. G-Strut.
 - e. Haydon Corporation.
 - f. Seasafe, Inc.; AMICO, a Gibraltar Industries Company.
 - g. **<Insert manufacturer's name>.**
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Channel Width: Selected for applicable load criteria 1-5/8 inches (41.25 mm) 1-1/4 inches (31.75 mm) 13/16 inches (20.64 mm) Insert dimension.
 4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 5. Fitting and Accessory Materials: Same as those for channels and angles, except metal items may be stainless steel.
 6. Rated Strength: Selected to suit applicable load criteria.
 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- D. Conduit and Cable Support Devices: Steel Steel and malleable-iron Stainless-steel Glass-fiber-resin hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) Hilti, Inc..
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc..
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc..
 - 5) Insert manufacturer's name.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, **[provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
 - 1) B-line, an Eaton business.
 - 2) Empire Tool and Manufacturing Co., Inc..
 - 3) Hilti, Inc..
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc..
 - 5) MKT Fastening, LLC.
 - 6) Insert manufacturer's name.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All Stainless-steel springhead type.
 - 7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

- B. Materials: Comply with requirements in Section 05 5000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
1. NECA 1.
 2. NECA 101
 3. NECA 102.
 4. NECA 105.
 5. NECA 111.
- B. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as **[required by] [scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in] NFPA 70**. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted **[or other]** support system, sized so capacity can be increased by at least **[25] <Insert number>** percent in future without exceeding specified design load limits.
1. Secure raceways and cables to these supports with **[two-bolt conduit clamps] [single-bolt conduit clamps] [single-bolt conduit clamps using spring friction action for retention in support channel]**.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, **[EMT] [IMC] [and] [RMC]** may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: [**Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts**] [**Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69**] [**Spring-tension clamps**].
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate[**by means that comply with seismic-restraint strength and anchorage requirements**].
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 05 5000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use [3000-psi (20.7-MPa)] **<Insert value>**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in [**Section 03 3000 "Cast-in-Place Concrete."**] [**Section 03 3053 "Miscellaneous Cast-in-Place Concrete."**]
- C. Anchor equipment to concrete base as follows:
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in [Section 09 9113 "Exterior Painting"] [Section 09 9123 "Interior Painting"] [and] [Section 09 9600 "High-Performance Coatings"] <Insert painting Sections> for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Surface raceways.
 - 5. Boxes, enclosures, and cabinets.
 - 6. Handholes and boxes for exterior underground cabling.

1.2 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Sustainable Design Submittals:
 - 1. Product Data: For solvents and adhesives, indicating VOC content.
 - 2. Laboratory Test Reports: For solvents and adhesives, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer.
- B. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- C. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Allied Tube & Conduit; a part of Atkore International.
 - c. Anamet Electrical, Inc.
 - d. Calconduit.
 - e. Electri-Flex Company.
 - f. FSR Inc.
 - g. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - h. Republic Conduit.
 - i. Southwire Company.
 - j. Thomas & Betts Corporation; A Member of the ABB Group.
 - k. Topaz Electric; a division of Topaz Lighting Corp.
 - l. Western Tube and Conduit Corporation.
 - m. Wheatland Tube Company.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.
4. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit IMC.
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch (1 mm), minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.
7. FMC: Comply with UL 1; zinc-coated steel.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Manufacturers: As specified above.
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

- C. Joint Compound for IMC, GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

A. Nonmetallic Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AFC Cable Systems; a part of Atkore International.
 - b. Anamet Electrical, Inc.
 - c. Arnco Corporation.
 - d. CANTEX INC.
 - e. CertainTeed Corporation.
 - f. Electri-Flex Company.
 - g. Kraloy.
 - h. RACO; Hubbell.
 - i. Thomas & Betts Corporation; A Member of the ABB Group.
 - j. Topaz Electric; a division of Topaz Lighting Corp.
2. Listing and Labeling: Nonmetallic conduit shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ENT: Comply with NEMA TC 13 and UL 1653.
4. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
5. LFNC: Comply with UL 1660.
6. Rigid HDPE: Comply with UL 651A.
7. Continuous HDPE: Comply with UL 651A.
8. RTRC: Comply with UL 2515A and NEMA TC 14.

B. Nonmetallic Fittings:

1. Manufacturers: As specified above.
2. Fittings, General: Listed and labeled for type of conduit, location, and use.
3. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
 - a. Fittings for LFNC: Comply with UL 514B.
4. Solvents and Adhesives: As recommended by conduit manufacturer.
5. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. B-line, an Eaton business.
 2. Hoffman; a brand of Pentair Equipment Protection.
 3. MonoSystems, Inc.
 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Screw-cover type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect Prime coated, ready for field painting.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. MonoSystems, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Adalet.
 - 2. Crouse-Hinds, an Eaton business.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. FSR Inc.
 - 6. Hoffman; a brand of Pentair Equipment Protection.
 - 7. Hubbell Incorporated.
 - 8. Hubbell Incorporated; Wiring Device-Kellems.
 - 9. Kraloy.
 - 10. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 11. RACO; Hubbell.
 - 12. Spring City Electrical Manufacturing Company.
 - 13. Thomas & Betts Corporation; A Member of the ABB Group.
 - 14. Topaz Electric; a division of Topaz Lighting Corp.
 - 15. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: Fully adjustable Semi-adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- K. Gangable boxes are allowed.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- M. Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.6 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. NewBasis.
 - c. Oldcastle Enclosure Solutions.
 - d. Oldcastle Precast, Inc.
 - e. Quazite: Hubbell Power Systems, Inc.
 2. Standard: Comply with SCTE 77.
 3. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 6. Cover Legend: Molded lettering, "ELECTRIC." Insert legend.
 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 8. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete reinforced concrete cast iron hot-dip galvanized-steel diamond plate fiberglass.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company.
 - b. NewBasis.
 - c. Nordic Fiberglass, Inc.
 - d. Oldcastle Enclosure Solutions.
 - e. Oldcastle Enclosure Solutions.
 - f. Oldcastle Precast, Inc.
 - g. Quazite: Hubbell Power Systems, Inc.
 2. Standard: Comply with SCTE 77.
 3. Color of Frame and Cover: Gray Green.
 4. Configuration: Designed for flush burial with integral closed bottom unless otherwise indicated.
 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 7. Cover Legend: Molded lettering, "ELECTRIC." Insert legend.
 8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 9. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Tests of materials shall be performed by an independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: GRC.
 - 2. Concealed Conduit, Aboveground: GRC.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC direct buried or concrete encased as indicated.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed and Subject to Physical Damage: GRC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums.
 - e. **<Insert designations of applicable spaces or locations>.**
 - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 5. Damp or Wet Locations: GRC.
 - 6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
- F. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Complete raceway installation before starting conductor installation.
- G. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- H. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- I. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- J. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- K. Raceways Embedded in Slabs:
1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange raceways to keep a minimum of [1 inch (25 mm)] [2 inches (50 mm)] **<Insert dimension>** of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

- L. Stub-Ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- M. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- N. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- O. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- S. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- T. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- U. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- V. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.

3. Conduit extending from interior to exterior of building.
 4. Conduit extending into pressurized duct and equipment.
 5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 6. Where otherwise required by NFPA 70.
- W. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- X. Expansion-Joint Fittings:
1. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
 2. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- Y. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC in damp or wet locations not subject to severe physical damage.
- Z. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- AA. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- BB. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- CC. Locate boxes so that cover or plate will not span different building finishes.
- DD. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- EE. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- FF. Set metal floor boxes level and flush with finished floor surface.
- 3.3 INSTALLATION OF UNDERGROUND CONDUIT
- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 31 2000 "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.

2. Install backfill as specified in Section 31 2000 "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 31 2000 "Earth Moving."
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished grade.
- D. Install handholes with bottom below frost line, **<Insert depth of frost line below grade at Project site>** below grade.
- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wire-mesh cable tray.
 - 2. Cable tray accessories.
 - 3. Warning signs.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
 - 2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and sections, drawn to scale, and coordinated with each other, using input from installers of the items involved:
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design cable tray supports and seismic bracing.
- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAY

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
- B. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Structural Performance: See articles on individual cable tray types for specific values for the following parameters:
 - 1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 WIRE-MESH CABLE TRAY

- A. Description: Galvanized-steel wire mesh, complying with NEMA VE 1.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Industries; Cooper B-Line; GS Metals Corp.
 - 2. MP Husky USA Cable Tray & Cable Bus.
- C. Capacities and Characteristics:
 - 1. Width: 6 inches (150 mm) unless otherwise indicated on Drawings.
 - 2. Minimum Usable Load Depth: 4 inches (100 mm).
 - 3. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
 - 4. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb (90-kg) concentrated load, when tested according to NEMA VE 1.
 - 5. Class Designation: Comply with NEMA VE 1, Class 20A.
 - 6. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - 7. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
- D. Materials and Finishes:
 - 1. Steel:
 - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33
ASTM A 1008/A 1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A123/A123 M, Class B2.
 - 1) Hardware: Galvanized, ASTM B 633 Chromium-zinc plated,
ASTM F 1136 Stainless steel, Type 316.

- e. Finish: Hot-dipped galvanized after fabrication, complying with ASTM A 653/A 653M, G90 (Z275).
 - 1) Hardware: Galvanized, ASTM B 633 Chromium-zinc plated, ASTM F 1136.

2.4 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 WARNING SIGNS

- A. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background, with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Comply with Section 26 0553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable tray and support systems according to NEMA VE 2.
- B. Install cable tray as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable tray, so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Fasten cable tray supports to building structure.
- F. Design fasteners and supports to carry cable tray, cables, and a concentrated load of 200 lb (90 kg). Comply with requirements in Section 26 0529 "Hangers and Supports for Electrical Systems."
- G. Place supports, so that spans do not exceed maximum spans on schedules, and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of tray rungs.
- H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.

- I. Do not install more than one cable tray splice between supports.
- J. Make changes in direction and elevation using manufacturer's recommended fittings.
- K. Make cable tray connections using manufacturer's recommended fittings.
- L. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- M. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- N. Install cable trays with enough workspace to permit access for installing cables.
- O. Install barriers to separate cables of different systems, such as power, communications, and data processing, or of different insulation levels, such as 600, 5000, and 15 000 V.
- P. Install permanent covers, if used, after installing cable.
- Q. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- R. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch (1800-mm) intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
- D. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding-bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
- E. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."
- F. In existing construction, remove inactive or dead cables from cable trays.

3.3 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.

- B. Connect raceways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
 2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
 3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
 4. Verify that there are no intruding items, such as pipes, hangers, or other equipment, in the cable tray.
 5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
 6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquer in suspect areas.
 7. Check for improperly sized or installed bonding jumpers.
 8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.
- B. Prepare test and inspection reports.

3.5 PROTECTION

- A. Protect installed cable trays and cables.
 1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
 2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION

SECTION 26 0543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits and fittings, including GRC and PVC-coated steel conduit.
2. Rigid nonmetallic duct.
3. Flexible nonmetallic duct.
4. Duct accessories.
5. Precast concrete handholes.
6. Polymer concrete handholes and boxes with polymer concrete cover.
7. Precast manholes.
8. Utility structure accessories.

1.2 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
1. Two or more ducts installed in parallel, with or without additional casing materials.
 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
1. Include duct-bank materials, including spacers and miscellaneous components.
 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 3. Include accessories for manholes, handholes, boxes, and other utility structures.
 4. Include underground-line warning tape.
- B. Shop Drawings:
1. Precast or Factory-Fabricated Underground Utility Structures:
 - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include reinforcement details.
 - d. Include frame and cover design and manhole chimneys.

- e. Include ladder or step details.
 - f. Include grounding details.
 - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - h. Include joint details.
- 2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.5 MAINTENANCE MATERIALS SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

1.7 FIELD CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than five days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.
- B. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Coated Steel Conduit: PVC-coated GRC IMC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.
 - 3. Anamet Electrical, Inc.
 - 4. Calconduit.
 - 5. Electri-Flex Company.
 - 6. FSR Inc.
 - 7. Korkap.
 - 8. Opti-Com Manufacturing Network, Inc (OMNI).
 - 9. O-Z/Gedney; a brand of Emerson Industrial Automation.
 - 10. Perma-Cote.
 - 11. Picoma Industries, Inc.
 - 12. Plasti-Bond.
 - 13. Republic Conduit.
 - 14. Southwire Company.
 - 15. Thomas & Betts Corporation; A Member of the ABB Group.
 - 16. Topaz Electric; a division of Topaz Lighting Corp.
 - 17. Western Tube and Conduit Corporation.
 - 18. Wheatland Tube Company.
- D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-80-PVC and Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ARNCO Corp.
 - 2. Beck Manufacturing.
 - 3. CANTEX INC.
 - 4. CertainTeed Corporation.
 - 5. Condux International, Inc.
 - 6. Crown Line Plastics.
 - 7. ElecSys, Inc.
 - 8. Electri-Flex Company.
 - 9. Endot Industries Inc.

10. IPEX USA LLC.
11. Lamson & Sessions.
12. Manhattan/CDT.
13. National Pipe & Plastics.
14. Opti-Com Manufacturing Network, Inc (OMNI).
15. Spiraduct/AFC Cable Systems, Inc.

C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

D. Solvents and Adhesives: As recommended by conduit manufacturer.

1. VOC Content:[510] <Insert value> g/L or less for PVC conduit and fittings.

2.3 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. CANTEX INC.
 - c. Carlon; a brand of Thomas & Betts Corporation.
 - d. IPEX USA LLC.
 - e. PenCell Plastics.
 - f. Underground Devices, Inc.

B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 26 0553 "Identification for Electrical Systems."

C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.

1. Color: Red dye added to concrete during batching.
2. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Christy Concrete Products.
2. Elmhurst-Chicago Stone Co.
3. Oldcastle Precast, Inc.
4. Rinker Group, Ltd.
5. Riverton Concrete Products.

6. Utility Concrete Products, LLC.
 7. Utility Vault Co.
 8. Wausau Tile Inc.
- C. Comply with ASTM C 858 for design and manufacturing processes.
- D. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
1. Cover Hinges: Concealed, with hold-open ratchet assembly.
 2. Cover Handle: Recessed.
- E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- F. Cover Legend: Molded lettering, "ELECTRIC." as indicated for each service. Insert legend.
- G. Configuration: Units shall be designed for flush burial and have open closed integral closed bottom unless otherwise indicated.
- H. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
1. Center window location.
 2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
 4. Knockout panels shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
- I. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
 2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
- J. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
- 2.5 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER
- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armorcast Products Company.
 2. NewBasis.
 3. Oldcastle Enclosure Solutions.

4. Quazite: Hubbell Power Systems, Inc.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray Green.
- E. Configuration: Units shall be designed for flush burial and have open closed integral closed bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC." as indicated for each service. Insert legend.
- I. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.6 PRECAST MANHOLES

- A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C.
 1. Carder Concrete Products.
 2. Christy Concrete Products.
 3. Elmhurst-Chicago Stone Co.
 4. Oldcastle Precast, Inc.
 5. Rinker Group, Ltd.
 6. Riverton Concrete Products.
 7. Utility Concrete Products, LLC.
 8. Utility Vault Co.
 9. Wausau Tile Inc.
- D. Comply with ASTM C 858.
- E. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.

- F. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
1. Center window location.
 2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
 4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
- G. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
 2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.
- H. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.
- I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 UTILITY STRUCTURE ACCESSORIES

- A. Accessories for Utility Structures: Utility equipment and accessory items used for utility structure access and utility support, listed and labeled for intended use and application.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bilco Company (The).
 2. Campbell Foundry Company.
 3. Carder Concrete Products.
 4. Christy Concrete Products.
 5. EJ.
 6. Elmhurst-Chicago Stone Co.
 7. McKinley Iron Works, Inc.
 8. Neenah Foundry Company.
 9. NewBasis.
 10. Oldcastle Precast, Inc.
 11. Osburn Associates, Inc.
 12. Pennsylvania Insert Corporation.
 13. Quazite: Hubbell Power Systems, Inc.
 14. Rinker Group, Ltd.
 15. Riverton Concrete Products.
 16. Underground Devices, Inc.
 17. Utility Concrete Products, LLC.
 18. Utility Vault Co.

19. Wausau Tile Inc.
- C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B cast aluminum with milled cover-to-frame bearing surfaces; diameter, 26 inches (660 mm) 29 inches (725 mm).
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
 - b. Seal joints watertight using preformed plastic or rubber complying with ASTM C 990. Install sealing material according to sealant manufacturers' written instructions.
- D. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
- F. Pulling-in and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- G. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.
1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- H. Ground Rod Sleeve: 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.
- I. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
- J. Cable Rack Assembly: Steel, hot-rolled hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form a continuous unit; 1-1/2 inches (38 mm) in width by nominal 24 inches (600 mm) long; punched with 14 hook holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
 2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (450 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
- K. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
- L. Fixed Manhole Ladders: Arranged for attachment to roof or wall and floor of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin hot-dip galvanized steel.
- M. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater Light duty, designed for lifts less than 60 lbf (270 N). Two Insert number required.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 2. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.

- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Section 31 1000 "Site Clearing." Remove and stockpile topsoil for reapplication according to Section 31 1000 "Site Clearing."

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-80-PVC RNC, concrete-encased unless otherwise indicated.
- C. Duct for Electrical Branch Circuits: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.
- D. Underground Ducts Crossing Paved Paths Walks and Driveways: Type EPC-40 PVC RNC, encased in reinforced concrete.
- E. Stub-ups: Concrete-encased PVC-coated GRC.

3.3 EARTHWORK

- A. Excavation and Backfill: Comply with Section 31 2000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 32 9200 "Turf and Grasses" and Section 32 9300 "Plants."
- D. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to "Cutting and Patching" Article in Section 01 7300 "Execution."

3.4 DUCT AND DUCT-BANK INSTALLATION

- A. Install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm) , both horizontally and vertically, at other locations unless otherwise indicated.

- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. Terminator Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inches (150 mm) o.c. for 4-inch (100-mm) duct, and vary proportionately for other duct sizes.
1. Begin change from regular spacing to terminator spacing 10 feet (3 m) from the terminator, without reducing duct line slope and without forming a trap in the line.
 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line duct with calculated expansion of more than 3/4 inch (19 mm).
- H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 0544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- I. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- J. Pulling Cord: Install 200-lbf- (1000-N-) test nylon cord in empty ducts.
- K. Concrete-Encased Ducts and Duct Bank:
1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 2000 "Earth Moving" for pipes less than 6 inches (150 mm) in nominal diameter.
 2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
 3. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
 4. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.

5. **Spacer Installation:** Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 6. **Elbows:** Use manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
 7. **Reinforcement:** Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 8. **Forms:** Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 9. **Concrete Cover:** Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between duct of like services, and 4 inches (100 mm) between power and communications ducts.
 10. **Concreting Sequence:** Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
 - b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
 11. **Pouring Concrete:** Comply with requirements in "Concrete Placement" Article in Section 03 3000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
- L. **Direct-Buried Duct and Duct Bank:**
1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 2000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
 2. **Width:** Excavate trench 12 inches (300 mm) wider than duct on each side.
 3. **Width:** Excavate trench 3 inches (75 mm) wider than duct on each side.
 4. **Depth:** Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
 5. Set elevation of bottom of duct bank below frost line.
 6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.

7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 8. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 9. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inches (100 mm) over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 31 2000 "Earth Moving" for installation of backfill materials.
 - a. Place minimum 3 inches (75 mm) of sand as a bed for duct. Place sand to a minimum of 6 inches (150 mm) above top level of duct.
 - b. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.
 - M. Underground-Line Warning Tape: Bury conducting underground line specified in Section 26 0553 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks and approximately 12 inches (300 mm) below grade. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
- 3.5 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES
- A. Cast-in-Place Manhole Installation:
 1. Finish interior surfaces with a smooth-troweled finish.
 2. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
 3. Comply with requirements in Section 03 3000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.
 - B. Precast Concrete Handhole and Manhole Installation:
 1. Comply with ASTM C 891 unless otherwise indicated.
 2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

- C. Elevations:
1. Manhole Roof: Install with rooftop at least 15 inches (375 mm) below finished grade.
 2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
 3. Install handholes with bottom below frost line, below grade.
 4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
 5. Where indicated, cast handhole cover frame integrally with handhole structure.
- D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- E. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.
- F. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Section 07 1353 "Elastomeric Sheet Waterproofing." or Section 07 1354 "Thermoplastic Sheet Waterproofing." After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
- G. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 07 1113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- H. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, as required for installation and support of cables and conductors and as indicated.
- I. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- J. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
- 3.6 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE
- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.

- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
 - 1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Section 03 3000 "Cast-in-Place Concrete," with a troweled finish.
 - 2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.7 GROUNDING

- A. Ground underground ducts and utility structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum 12-inch- (300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
 - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

- B. Clean internal surfaces of manholes, including sump.
 - 1. Remove foreign material.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B. Related Requirements:
 - 1. Section 07 8413 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 - f. Insert manufacturer's name.
3. Sealing Elements: EPDM Nitrile (Buna N) rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
4. Pressure Plates: Carbon steel Plastic Stainless steel.
5. Connecting Bolts and Nuts: [**Carbon steel, with corrosion-resistant coating,**]
[**Stainless steel**] of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - a. Presealed Systems.
 - b. Insert manufacturer's name.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 2. Sealant shall have VOC content of <Insert value> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 9200 "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide [1/4-inch (6.4-mm)] <Insert dimension> annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed[**or unless seismic criteria require different clearance**].
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors [2 inches (50 mm)] <Insert dimension> above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 ACTION SUBMITTALS**

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS**2.1 PERFORMANCE REQUIREMENTS**

- A. Comply with ASME A13.1[**and IEEE C2**].
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Comply with **NFPA 70E and Section 26 0573.19 "Arc-Flash Hazard Analysis"** requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), **ambient**; 180 deg F (100 deg C), **material surfaces**.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. **Black letters on an orange field.**
 - 2. Legend: Indicate voltage **and system or service type**.
- B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded conductors.
 - 1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.

2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 3. Colors for 240-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 4. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 5. Color for Neutral:
 - a. 208/120-V or 120/240-V Circuits: **White**.
 - b. 480/277-V Circuits: Grey.
 6. Color for Equipment Grounds: **Green**.
 7. Colors for Isolated Grounds: Green with two or more yellow stripes.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
1. Black letters on an orange field.
 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:
1. Identify system voltage with black letters on an orange background.
- E. Warning labels and signs shall include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 2. **<Insert names and wording of warning signs or labels (for example, arc flash, multiple services and voltages, and others>.**
- F. Equipment Identification Labels:
1. Black letters on a white field.
 2. **<Insert specific requirements for equipment to be labeled, such as transformers, panelboards, etc.>**
- 2.3 MANUFACTURERS
- A. Subject to compliance with requirements, provide products by the following:
1. Brady Corporation.
 2. Carlton Industries, LP.
 3. Champion America.
 4. emedco.
 5. Hellermann Tyton
 6. Ideal Industries, Inc.
 7. LEM Products Inc.
 8. Marking Services, Inc.
 9. Panduit Corp.
 10. Seton Identification Products.

2.4 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
- B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted Write-on, 3-mil- (0.08-mm-) thick, polyester vinyl flexible label with acrylic pressure-sensitive adhesive.
 - 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 - 2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.
- D. Self-Adhesive Labels: Polyester Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
 - b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
 - c. As required by authorities having jurisdiction.

2.5 BANDS AND TUBES

- A. Snap-around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters and that stay in place by gripping action.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameter and shrunk to fit firmly. Full shrink recovery occurs at a maximum of 200 deg F (93 deg C). Comply with UL 224.

2.6 TAPES AND STENCILS

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide; compounded for outdoor use.
- C. Floor Marking Tape: 2-inch- (50-mm-) wide, 5-mil (0.125-mm) pressure-sensitive vinyl tape, with black and white yellow and black stripes and clear vinyl overlay.
- D. Underground-Line Warning Tape:
 - 1. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical [**and communications**] utility lines.

- b. Printing on tape shall be permanent and shall not be damaged by burial operations.
- c. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- 2. Color and Printing:
 - a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE" <Insert inscription>.
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE" <Insert inscription>.
- 3. Tag: [Type I] <Insert drawing designation>:
 - a. Pigmented polyolefin, bright colored, [**continuous-printed on one side with the inscription of the utility,**] compounded for direct-burial service.
 - b. Width: 3 inches (75 mm).
 - c. Thickness: 4 mils (0.1 mm).
 - d. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
 - e. Tensile according to ASTM D 882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).
- 4. Tag: [Type II] <Insert drawing designation>:
 - a. Multilayer laminate, consisting of high-density polyethylene scrim coated with pigmented polyolefin; bright colored, [**continuous-printed on one side with the inscription of the utility,**] compounded for direct-burial service.
 - b. Width: 3 inches (75 mm).
 - c. Thickness: 12 mils (0.3 mm).
 - d. Weight: 36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).
 - e. Tensile according to ASTM D 882: 400 lbf (1780 N) and 11,500 psi (79.2 MPa).
- 5. Tag: Type ID Insert drawing designation:
 - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, [**continuous-printed on one side with the inscription of the utility,**] compounded for direct-burial service.
 - b. Width: 3 inches (75 mm).
 - c. Overall Thickness: 5 mils (0.125 mm).
 - d. Foil Core Thickness: 0.35 mil (0.00889 mm).
 - e. Weight: 28 lb/1000 sq. ft. (13.7 kg/100 sq. m).
 - f. Tensile according to ASTM D 882: 70 lbf (311.3 N) and 4600 psi (31.7 MPa).
- 6. Tag: Type IID Insert drawing designation:
 - a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright-colored, [**continuous-printed on one side with the inscription of the utility,**] compounded for direct-burial service.
 - b. Width: 3 inches (75 mm).
 - c. Overall Thickness: 8 mils (0.2 mm).
 - d. Foil Core Thickness: 0.35 mil (0.00889 mm).
 - e. Weight: 34 lb/1000 sq. ft. (16.6 kg/100 sq. m).
 - f. Tensile according to ASTM D 882: 300 lbf (1334 N) and 12,500 psi (86.1 MPa).

- E. Stenciled Legend: In nonfading, waterproof, black Insert color ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.7 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking cable tie fastener.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch (0.38 mm) 0.023 inch (0.58 mm) thick, color-coded for phase and voltage level, with factory screened printed permanent designations; punched for use with self-locking cable tie fastener.
 - 1. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.8 SIGNS

- A. Baked-Enamel Signs:
 - 1. Preprinted aluminum signs, **[high-intensity reflective,]**punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal Size: 7 by 10 inches (180 by 250 mm).
- B. Metal-Backed Butyrate Signs:
 - 1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch (1-mm) galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
 - 2. 1/4-inch (6.4-mm) grommets in corners for mounting.
 - 3. Nominal Size: 10 by 14 inches (250 by 360 mm).
- C. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Engraved legend.
 - 2. Thickness:
 - a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
 - c. Engraved legend with **[black letters on white face] [white letters on a dark gray background] <Insert colors>**.
 - d. **[Punched or drilled for mechanical fasteners with 1/4-inch (6.4-mm) grommets in corners for mounting] [Self-adhesive]**.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.9 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black, except where used for color-coding.

- B. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 Deg F (23 Deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - 5. Color: Black.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.
- I. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- J. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for **power transfer, load shedding, etc..**
- K. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- L. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:
 1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
- M. Vinyl Wraparound Labels:
 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
- N. Snap-around Labels: Secure tight to surface at a location with high visibility and accessibility.
- O. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- P. Self-Adhesive Labels:
 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
- Q. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.
- R. Heat-Shrink, Preprinted Tubes: Secure tight to surface at a location with high visibility and accessibility.
- S. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- T. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
 1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

- U. Floor Marking Tape: Apply stripes to finished surfaces following manufacturer's written instructions.
- V. Underground Line Warning Tape:
 1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [**or concrete envelope**] exceeds 16 inches (400 mm) overall.
 2. Limit use of underground-line warning tape to direct-buried cables.
 3. Install underground-line warning tape for direct-buried cables and cables in raceways.
- W. Tags:
 1. Place in a location with high visibility and accessibility.
 2. Secure using **general-purpose** or **plenum-rated** cable ties.
- X. Signs:
 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on minimum 1-1/2-inch- (38-mm-) high sign; where two lines of text are required, use signs minimum 2 inches (50 mm) high.
- Y. Cable Ties: General purpose, for attaching tags, except as listed below:
 1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.
- C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch- (75-mm-) high, black letters on 20-inch (500-mm) centers.
 1. Locate identification at changes in direction, at penetrations of walls and floors, and at 30-foot (10-m) maximum intervals.
- D. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Vinyl wraparound labels Snap-around labels Self-adhesive labels.
 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- E. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than [30] <Insert number> A and [120] <Insert number> V to Ground: Identify with self-adhesive [**raceway labels**] [**vinyl tape applied in bands**].

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- F. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:
1. "EMERGENCY POWER."
 2. "POWER."
 3. "UPS."
- G. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **snap-around color-coding bands** or **self-adhesive vinyl tape** to identify the phase.
1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- H. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use **nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation**.
- I. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use **self-adhesive labels** with the conductor or cable designation, origin, and destination.
- J. Control-Circuit Conductor Termination Identification: For identification at terminations, provide **self-adhesive labels** with the conductor designation.
- K. Conductors to Be Extended in the Future: Attach **marker tape** to conductors and list source.
- L. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- M. Concealed Raceways and Duct Banks, More Than 600 V, within Buildings: Apply floor marking tape to the following finished surfaces:
1. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
 2. Wall surfaces directly external to raceways concealed within wall.
 3. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
- N. Workspace Indication: Apply floor marking tape and stencil to finished surfaces. Show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- O. Instructional Signs: Self-adhesive labels, including the color code for grounded and ungrounded conductors.

- P. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: **Baked-enamel warning signs** or Metal-backed, butyrate warning signs.
1. Apply to exterior of door, cover, or other access.
 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- Q. Arc Flash Warning Labeling: Self-adhesive labels.
- R. Operating Instruction Signs: **Baked-enamel warning signs**, [Metal-backed, butyrate warning signs or **Laminated acrylic or melamine plastic signs**.
- S. Emergency Operating Instruction Signs: **Baked-enamel warning signs**, **Metal-backed, butyrate warning signs**, [Laminated acrylic or melamine plastic signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for **power transfer, load shedding**, etc..
- T. Equipment Identification Labels:
1. Indoor Equipment: Laminated acrylic or melamine plastic sign Self-adhesive sign.
 2. Outdoor Equipment: **Laminated acrylic or melamine sign**.
 3. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of an engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchgear.
 - e. Switchboards.
 - f. Transformers: Label that includes tag designation indicated on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - g. Substations.
 - h. Emergency system boxes and enclosures.
 - i. Motor-control centers.
 - j. Enclosed switches.
 - k. Enclosed circuit breakers.
 - l. Enclosed controllers.
 - m. Variable-speed controllers.
 - n. Push-button stations.
 - o. Power-transfer equipment.
 - p. Contactors.
 - q. Remote-controlled switches, dimmer modules, and control devices.
 - r. Battery-inverter units.
 - s. Battery racks.
 - t. Power-generating units.
 - u. Monitoring and control equipment.
 - v. UPS equipment.
 4. Include the following information on equipment labels:
 - a. Equipment Identification per the Drawings
 - b. Source of power: (e.g., "Fed From PP-1A")

- c. What is fed (e.g., "Feeds EF-3")

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0573 – POWER SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices, overcurrent protective device settings for selective tripping, and the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

- A. Submit study reports indicated in this section prior to receiving final approval of the distribution equipment submittals, including but not limited to panelboards, transformers, switchboards, switchgear, substations, transfer switches, generators, motor controllers, and disconnect switches. If formal completion of studies will cause delay in equipment manufacturing, provide preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
- B. Submit the following in digital form:
 - 1. Power system study input data, including completed computer program input data sheets.
 - 2. Power system study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - a. Revised single-line diagram, reflecting field investigation results and results of power system studies.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Power System Study Specialist.
- B. Product Certificates: For power system study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Short-Circuit Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Power System Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the International Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

- A. Software Developers: Subject to compliance with requirements, perform studies utilizing software by one of the following:
 - 1. ESA Inc., EasyPower
 - 2. SKM Systems Analysis, Inc.
 - 3. ETAP.
- B. Comply with IEEE 399 and IEEE 551.
- C. Analytical features of fault-current-study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Comments and recommendations for system improvements, where needed.
- E. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 - 3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.
- G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

2.3 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 1. Protective device designations and ampere ratings.
 2. Cable size and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Protective Device Coordination Study:
 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.

- b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.
 - F. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
 - 1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
 - 2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
 - 3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 - 4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current.
 - e. Ground-fault protective devices.
 - f. The largest feeder circuit breaker in each motor-control center and panelboard.
 - 5. Provide adequate time margins between device characteristics such that selective operation is achieved.
 - 6. Comments and recommendations for system improvements.

2.4 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Arc-Flash Study Output:
 - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.

- c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- F. Incident Energy and Flash Protection Boundary Calculations:
- 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Working distance.
 - 6. Incident energy.
 - 7. Hazard risk category.
 - 8. Recommendations for arc-flash energy reduction.
 - 9. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the study.
- 1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
 - 2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Electrical Survey Data: Gather and tabulate the following input data to support the power system study:
- 1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 - 2. Obtain electrical power utility impedance at the service.
 - 3. Power sources and ties.
 - 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 - 5. For generators, include voltage rating, power rating (kW/kVA), and alternator sub-transient reactance values.
 - 6. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 - 7. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
 - 8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 - 9. Motor horsepower and NEMA MG 1 code letter designation.
 - 10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. The extent of the electrical power system to be studied is indicated on Drawings.
- D. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less, or as required to satisfy coordination study and arc-flash study requirements.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. The calculations shall include the ac fault-current decay from induction motors. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- G. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:
 - 1. Electric utility's supply termination point.
 - 2. Generators.
 - 3. Incoming switchgear.
 - 4. Low-voltage switchgear.
 - 5. Motor-control centers.
 - 6. Control panels.
 - 7. Automatic transfer switches.
 - 8. Power distribution panelboards.
 - 9. Branch circuit panelboards.
 - 10. Disconnect switches.
 - 11. **<Insert significant locations in the system>.**
- H. Equipment short-circuit ratings and protective device interrupting ratings shall be selected based on the results of the fault current study.

3.3 PROTECTIVE DEVICE COORDINATION STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

- C. Evaluate overcurrent protective devices serving transformers and verify that the devices will not open upon energization of the transformer. Where device rating and/or type must be changed to avoid opening upon energization, notify the Contractor and Architect and record recommended device changes in the report.
- D. Evaluate overcurrent protective device coordination against project selective coordination criteria. Where the system devices and/or configuration cannot achieve the required selective coordination criteria, evaluate alternate overcurrent device selections that will meet the criteria and record recommendations in the report.

3.4 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Calculate maximum and minimum contributions of fault-current size.
 - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- C. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- D. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- E. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
- F. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the work location.
- G. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.
- H. Labels: Print and install labels for each modeled piece of electrical equipment. Provide green bordered labels for PPE category 0 & 1, yellow bordered labels for PPE category 2 & 3, and red bordered labels for PPE category 4 & dangerous. Labels shall have flash protection and shock protection and shall include:
 - 1. Flash Hazard in inches
 - 2. Arc Flash rating in cal/sq. cm
 - 3. Flash protection boundary in inches
 - 4. Glove class
 - 5. PPE clothing category
 - 6. Shock hazard in volts

7. Limited Approach distance in inches
8. Restricted Approach distance in inches
9. Prohibited Approach distance in inches
10. Bus Designation
11. Upstream overcurrent protection designation
 - a. Where applicable: Indication if values are based on “maintenance mode” on or off. Where temporary settings are utilized in the upstream overcurrent protection device for arc energy reduction purposes, provide two separate labels for each condition.
12. Oversize print of Warning or Danger

3.5 ADJUSTING

- A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.
- B. Set field-adjustable overcurrent protective devices to the recommended settings based on results from the power systems studies.

3.6 DEMONSTRATION

- A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 26 0800 - COMMISSIONING OF ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes Cx process requirements for the following electrical components, systems, assemblies, and equipment:
1. Electrical equipment connected to Normal power systems, including the following:
 - a. Motor-control centers.
 - b. Transformers.
 - c. **[Primary] [and] [secondary]** service electrical systems.
 - d. **[Distribution] [and] [branch-circuit]** panelboards.
 - e. Lightning protection systems.
 - f. Grounding systems.
 2. Electrical equipment connected to Essential power systems that provide an alternative source of power in the absence of power from the Normal power system, including the following:
 - a. Motor-control centers.
 - b. **[Primary] [and] [secondary]** service electrical systems.
 - c. **[Distribution] [and] [branch-circuit]** panelboards.
 - d. Lighting protection systems.
 - e. Grounding systems.
 - f. Generators.
 - g. UPS.
 3. Controls and instrumentation, including the following:
 - a. Equipment monitoring systems.
 - b. Energy monitoring and control systems.
 - c. Electrical metering and metering system.
 - d. Demand response systems.
 - e. Lighting control systems.
 - f. Security systems.
 - g. Fire-alarm systems.
 - h. **<Insert systems>**.
 4. Systems testing and verification, including **[Normal] [and] [Essential]** power systems[, **and transitions from Normal to Essential power systems and back**].
 5. **<Insert electrical systems>**.
- B. Related Requirements:
1. Section 01 9113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.

1.2 DEFINITIONS

- A. BoD: Basis-of-Design Document, as defined in Section 01 9113 "General Commissioning Requirements."
- B. Cx: Commissioning, as defined in Section 01 9113 "General Commissioning Requirements."

- C. CxA: Commissioning Authority, as defined in Section 01 9113 "General Commissioning Requirements."
- D. Essential Power Systems: A power system that a facility transitions to in the absence of Normal power. This power includes all systems classified as "standby" or "emergency," including "legally required."
- E. Low Voltage: 600 V and below.
- F. Medium Voltage: 601 V and above.
- G. Normal Power Systems: A power system that provides primary power to a facility.
- H. OPR: Owner's Project Requirements, as defined in Section 01 9113 "General Commissioning Requirements."
- I. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For **[BAS]** **[and]** **[electrical]** testing technician.
- B. Construction Checklists: Draft construction checklists will be created by CxA for Contractor review.
- C. Construction Checklists: Include the following and comply with requirements in Section 01 9113 "General Commissioning Requirements" for construction checklists:
 - 1. Instrumentation and control for electrical systems.
 - 2. Instrumentation and control for lighting control systems.
 - 3. Low-voltage power cables.
 - 4. Control voltage power cables.
 - 5. Electrical feeders and branch circuits.
 - 6. Liquid-filled transformers.
 - 7. Dry-type transformers.
 - 8. Instrument transformers.
 - 9. Switchgear and switchboard assemblies rated 1200 A or greater.
 - 10. Metal-enclosed bus duct.
 - 11. Busway.
 - 12. Motor-control centers.
 - 13. Low-voltage motor starters.
 - 14. Low-voltage air circuit breakers.
 - 15. Low-voltage insulated case circuit breakers.
 - 16. Low-voltage network protectors.
 - 17. Low-voltage air switches.
 - 18. Low-voltage surge protective devices.
 - 19. Medium-voltage power cables.
 - 20. Medium-voltage circuit breakers.
 - 21. Medium-voltage motor starters.

22. Medium-voltage air circuit breakers.
23. Medium-voltage vacuum circuit breakers.
24. Medium-voltage SF6 (sulfur hexafluoride) circuit breakers.
25. Medium-voltage air switches.
26. Medium-voltage surge protective devices.
27. Protective relays.
28. Metering devices.
29. Molded-case circuit breakers.
30. Low-voltage power circuit breakers.
31. Grounding systems.
32. Ground-fault protection systems.
33. Panelboards.
34. Receptacles and devices.
35. Engine generators.
36. Automatic transfer switches.
37. Variable-frequency drives.
38. AC synchronous motors and generators.
39. AC induction motors and generators.
40. DC motors and generators.
41. Battery systems.
42. Battery chargers.
43. Flooded lead-acid batteries.
44. Flooded lead-calcium batteries.
45. VRLA batteries.
46. UPS systems.
47. Power factor correction equipment, including capacitors, dry-type reactors (both shunt and current-limiting), and liquid-filled reactors (both shunt and current-limiting).
48. Lighting.
49. Vehicle charging equipment.
50. <Insert equipment>.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electrical systems and components to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Testing Technician Qualifications: Technicians to perform electrical Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 1. Journey level or equivalent skill level. Vocational school four-year-program graduate or an Associate's degree in electrical systems, or similar field. Degree may be offset by three years' experience as an apprentice or a journey-level electrician. Generally, required knowledge includes electrical and HVAC&R concepts, building operations, and application and use of tools and instrumentation to measure performance of electrical equipment, assemblies, and systems.
 2. Minimum [**three years'**] <Insert time> experience installing, servicing, and operating systems manufactured by approved manufacturer.

- B. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:
1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
 - a. Equipment/instrument identification number.
 - b. Planned Cx application or use.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 2. Test equipment and instrumentation shall meet the following criteria:
 - a. Capable of testing and measuring performance within the specified acceptance criteria.
 - b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - c. Be maintained in good repair and operating condition throughout duration of use on Project.
 - d. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- C. Proprietary Test Instrumentation and Tools:
1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
 - a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
 - 1) Instrument or tool identification number.
 - 2) Equipment schedule designation of equipment for which the instrument or tool is required.
 - 3) Manufacturer, make, model, and serial number.
 - 4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

- A. Prepare detailed construction checklists for electrical systems, subsystems, equipment, and components. Complete and submit construction checklists.

3.2 CONSTRUCTION CHECKLIST REVIEW

- A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.
- B. Return draft Construction Checklist review comments within [10] <Insert number> days of receipt.
- C. When review comments have been resolved, CxA will provide final construction checklists, marked "Approved for Use, (date)."
- D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 GENERAL TESTING REQUIREMENTS

- A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.
- B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.
- E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.
- F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.
 - 1. Contributors to development of construction checklists shall include, but are not limited to, the following:
 - a. Electrical systems and equipment installers.
 - b. Electrical instrumentation and controls installers.
- G. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.

3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- J. Coordinate schedule with, and perform Cx activities at the direction of the CxA.
- K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.
- L. Provide technicians, instrumentation, tools, and equipment to complete and document the following:
 1. Performance tests.
 2. Demonstration of a sample of performance tests.
 3. Cx tests.
 4. Cx test demonstrations.

3.4 Cx TESTS FOR ELECTRICAL SYSTEMS

- A. Verification of Normal Power System Operation:
 1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal power system.
 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
 3. Test Purpose: Verify operation of Normal power system.
 4. Test Conditions: Energize components of Normal power system, one at a time.
 5. Acceptance Criteria: Proper operation of Normal power system over a [24] [48] <Insert number>-hour period.
- B. Verification of Essential Power System Operation:
 1. Prerequisites:
 - a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential power system.
 - b. Completion of "Verification of Normal Power System Operation" tests.
 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
 3. Test Purpose: Verify operation of Essential power system.
 4. Test Conditions:
 - a. Energize components of Normal power system.
 - b. Simulate a failure of Normal power system.
 5. Acceptance Criteria: Transfer of power from Normal to Essential power system within OPR.
- C. Verification of Control and Instrumentation:
 1. Prerequisites: Acceptance of results for construction checklists.
 - a. Section 26 0913 "Electrical Power Monitoring and Control."
 - b. Section 26 0926 "Lighting Control Panelboards."

- c. Section 26 0936 "Modular Dimming Controls."
 - d. Section 26 0943.16 "Addressable-Luminaire Lighting Controls."
 - e. Section 26 0943.23 "Relay-Based Lighting Controls."
 - f. Section 26 2713 "Electricity Metering."
 - g. Section 26 3533 "Power Factor Correction Equipment."
- D. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential power systems.
- E. Test Conditions:
 - 1. Energize components of Normal power system.
 - 2. Test operation of equipment.
- F. Acceptance Criteria: Operation of equipment according to OPR.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0913 - ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes equipment and systems used to monitor and control electrical consumption:
 - 1. Multifunction meters.
 - 2. Electrical power monitoring system software.
 - 3. Electrical power monitoring and control software.
 - 4. Network configuration software.
 - 5. Monitoring and control of power distribution equipment.
 - 6. System operator interfaces.
 - 7. Desktop workstations.
 - 8. Portable workstations.
 - 9. Raceways and boxes.
 - 10. Wires and cables.
 - 11. Identification.
- B. Related Requirements:
 - 1. Section 23 0923.13 "Energy Meters" for electricity meters for HVAC equipment.
 - 2. Section 26 2713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.

1.2 DEFINITIONS

- A. Active Power: The average power consumed by a unit. Also known as "real power."
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. Apparent (Phasor) Power: " $S = VI$ " where "S" is the apparent power, "V" is the rms value of the voltage, and "I" is the rms value of the current.
- D. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- E. KY Pulse: A method of measuring consumption of electricity that is based on a relay operating like a SPST switch.
- F. KYZ Pulse: A method of measuring consumption of electricity based on a relay operating like a SPDT switch.
- G. LAN: Local area network.
- H. L-G: Line to ground.
- I. L-L: Line to line.
- J. L-N: Line to neutral.

- K. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
- L. Modbus TCP/IP: An open protocol for exchange of process data.
- M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- N. N-G: Neutral to ground.
- O. Power Factor: The ratio of active power to apparent power, sometimes expressed in percentage.
- P. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- Q. TCP/IP: Transport control protocol/Internet.
- R. UPS: Uninterruptible power supply; used both in singular and plural context.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for power monitoring and control.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: Indicating that computers used by the system are certified by ENERGY STAR.
- C. Shop Drawings: For power monitoring and control equipment.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, method of field assembly, components, and location and size of each field connection.
 - a. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
 - 1) Location of the meters and gateways, and routing of the connecting wiring.
 - 2) Details of power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
 - 3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
 - 4. Network naming and numbering scheme.
 - 5. Include diagrams for power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
 - 6. Specifications for workstations.

7. UPS sizing calculations for workstation.
8. Surge Suppressors: Data for each device used and where applied.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Design Data:
 1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format on compact disk or portable storage device with a USB interface.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to do the following:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on compact disk or portable storage device with a USB interface.
 - j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - k. Complete original-issue copies of furnished software, including operating systems, custom programming language, workstation software, and graphics software on compact disk or portable storage device with a USB interface.
 - l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 - m. Owner training materials.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power monitoring and control units to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.

2. Software licenses.
3. Software service agreement.
4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Provide separately for each PC.
5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on compact disk or portable storage device with a USB interface of the hard-copy submittal.
6. Program Software Backup: On compact disk or portable storage device with a USB interface, complete with data files.
7. Device address list.
8. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
 2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.8 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
 1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control of electrical power distribution system(s) that includes the following:
 1. Electrical meters that monitor, control, and connect to the data transmission network.
 2. LAN: High-speed, multi-access, open, nonproprietary, industry-standard communication protocols.
 3. Include PC-based workstation with web access, with its operating system and application software, connected to data transmission network.
- B. The electrical power monitoring and control system shall be Internet based.
 1. System software shall be based on server thin-client architecture, designed around open standards of internet technology.

2. Intent of thin-client architecture is to provide operators complete access to power monitoring and control system via an Internet browser. No special software other than an Internet browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
 3. Internet access shall be password protected.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. UL Compliance: Listed and labeled as complying with UL 61010-1.

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 26 4313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
- B. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.
- C. Interface with DDC System for HVAC: Provide factory-installed hardware and software to enable the DDC system for HVAC to monitor, display, and record data for use in processing reports.
1. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), **power factor** <Insert monitoring point>.
 2. **[ASHRAE 135 (BACnet)] [LonTalk] [Modbus] [Industry-accepted, open-protocol]** <Insert type of interface> communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely monitor meter information from a DDC system for HVAC workstation. Control features and monitoring points displayed locally at metering panel shall be available through the DDC system for HVAC.
- D. Backup Power Source:
1. Electrical power distribution equipment served by a backup power source for controls shall have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 MULTIFUNCTION ENERGY METERS <Insert drawing designation>

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
 2. General Electric Company.
 3. Schneider Electric USA, Inc.

- B. Multifunction Energy Meter: Separately mounted, modular, permanently installed, solid-state, digital I/O instrument for power and energy metering and monitoring; complying with UL 61010-1.
1. Capable of metering 4-wire Y, 3-wire Y, 3-wire delta, and single-phase power systems.
 2. Equipped with security lock to protect revenue related metering from unauthorized and accidental changes.
- C. Environment: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of minus 4 deg to 158 deg F (minus 20 to plus 70 deg C) dry bulb and 5 to 95 percent relative humidity, noncondensing.
 2. Comply with IEC 60529 degree of protection code of IP65 for the front of the meter, and code of IP30 for the body.
- D. Overvoltage: Comply with UL 61010-1 overvoltage withstand rating for CAT III.
- E. Accuracy:
1. Comply with ANSI C12.20, Class 0.5.
 2. Neutral Current Measurement: Not more than 0.65 percent.
 3. Power Factor: 1.0 percent.
 4. Frequency: 0.1 percent.
 5. THD: 1.0 percent.
 6. Waveform Sampling: 64 per cycle.
- F. Data Link:
1. RS-485 Modbus, RTU protocol, [2] [4]-wire connection to host devices with a compatible port.
- G. Meter Physical Characteristics:
1. Display: Backlit LCD with antiglare and scratch-resistant lens.
 2. Display of Metered Values:
 - a. One screen to show at least three user-selected values displayed at the same time. Selections available to display shall include the following:
 - 1) All meters.
 - 2) Measurements.
 - 3) THD.
 - 4) Energy.
 - 5) Demand.
 - 6) Minimum and maximum values.
 - 7) Power demand.
- H. Sampling Rate: Continuously sample and record voltage and current at a rate not less than 64 Insert number samples per cycle, simultaneously on all voltage and current channels of the meter.
- I. Meters:
1. Instantaneous, rms:
 - a. Current: Each phase, neutral and three-phase average.

- b. Voltage: L-L each phase, L-L three-phase average, L-N each phase, and L-N three-phase average.
 - c. Active Power (kW): Each phase and three-phase total.
 - d. Reactive Power (kVAR): Each phase and three-phase total.
 - e. Apparent Power (kVA): Each phase and three-phase total.
 - f. Power Factor: Each phase and three-phase total.
 - 2. Energy:
 - a. Active Energy (kWh): Three-phase total.
 - 3. Demand, Derived from Instantaneous rms Meters:
 - a. Current: Present and maximum.
 - b. Active: Present and maximum.
 - c. Reactive: Present and maximum.
 - d. Apparent: Present and maximum.
 - 4. Power Quality Measurements:
 - a. THD: Current and voltage from measurements simultaneously from the same cycle, as can be calculated from the specified sampling rate.
- J. I/O: Two optically isolated digital outputs for KY pulsing or control. Output signal characteristics shall be 150 mA at 200 V.
- 1. KY Pulse: Generate standard KY pulses for a user-defined increment of metered active energy as follows:
 - a. User-defined pulse output, associated with kWh.
 - b. User-defined pulse output, associated with kVARh.
- K. Capacities and Characteristics:
- 1. Power Supply: 120-V ac, 60 Hz.
 - 2. Circuit Connections:
 - a. Voltage: Measurement autoranging, 60- to 400-V ac L-N. Connect directly to low-voltage (600 V and less) without using voltage transformers. Meter impedance shall be 2-megohm L-L or greater. Overload Tolerance: 1500-V ac, rms, continuously.
 - b. Current: Connect to instrument grade current transformer with a metering range of 5 mA to 6 A. Overcurrent tolerance of the instrument shall be 10 A continuous, 50 A for 10 seconds once per hour, and 120 A for one second per hour.
 - c. Frequency: 45 to 65 Hz.
 - d. Time: Input from a GPS receiver to synchronize the internal clock of the instrument and to time-synchronize this instrument with the network to a deviation of not greater than 1 ms.
- 2.4 PC OPERATING SYSTEM SOFTWARE
- A. Description: System software shall monitor, analyze, display, control, and save all the parameters and features available at the connected meter.
 - B. Software: Configured to run on a portable laptop computer, a single PC, or a tablet computer, with capability for accessing a single meter at a time, at the location of the meter. System is not connected to LAN.
 - C. Minimum Requirements:
 - 1. Real-time multitasking and multiuser [32-] [or] [64-]bit operating system that allows execution of multiple real-time programs and custom program development.

2. Operating system shall be capable of operating Microsoft Windows applications.
3. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

2.5 NETWORKED PC OPERATING SYSTEM SOFTWARE

- A. Description: System software shall monitor, analyze, display, control, and save parameters and features available at each of the connected meters.
- B. Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be web enabled.
- C. System Software Minimum Requirements:
 1. Real-time multitasking and multiuser [32-] [or] [64-]bit operating system that allows concurrent multiple workstations operating and concurrent execution of multiple real-time programs and custom program development.
 2. Operating system shall be capable of operating Microsoft Windows applications.
 3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
 4. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.
- D. Operator Interface Software:
 1. Minimize operator training through use of English language prorating and English language point identification.
 2. Minimize use of a typewriter-style keyboard through use of a pointing device, touchscreen, or mouse.
 3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
 4. Automatic sign-off period shall be programmable from 1 to 60 minutes in 1-minute increments on a per operator basis.
 5. Record operator sign-on and sign-off activity.
 6. Security Access:
 - a. Operator access to electrical monitoring and control system shall be under password control.
 - b. An alphanumeric password shall be user assignable to each operator.
 - c. Software shall have at least five access levels.
 - 1) View - View information. No change privileges allowed.
 - 2) User - Same as View, but is able to initiate control functions.
 - 3) Controller - Same as User, but is able to initiate communications.
 - 4) Operator - Same as Controller, but is able to modify configurations.
 - 5) Supervisor - Same as Operator, but is able to administer security privileges.
 - d. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator-assigned access level(s) and menu-item access level(s) is required to gain access to menu item.
 - e. Display menu items to operator with those menu items capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.

E. Graphic Interface Software:

1. Include a full interactive graphical selection means of accessing and displaying system data to operator.
2. Descriptors for graphics, points, alarms, and such shall be modified through workstation under password control.
3. Display operator accessed data on the monitor.
4. Help Features: On-line context-sensitive help utility to facilitate operator training and understanding.

2.6 POWER MONITORING AND CONTROL SOFTWARE

A. Data Storage and Data Sharing:

1. Query and download logs of interval data stored on metering devices.
2. Query and download logs of alarm and event data stored on metering devices.
3. Query and download logs of waveform capture data stored on metering devices.
4. Query and download logs of interval data generated by the software and calculated by the meters.
5. Query and download logs of alarm and event data generated by the software and calculated by the meters.
6. Automatically re-arm the waveform recorders, on upload of information.
7. Provide a facility to archive, trim, and back up the database on demand, or on a schedule.
8. Provide a facility to view historical data from archived databases.
9. Support user changes to the database.
 - a. Support on-line changes while the data storage/retrieval application is running.
 - b. Suffer no interruption to its operation while changes are being made.
 - c. Require no restart once the configuration has been performed.

B. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by the electrical power monitoring and control system.
2. Plan for each building floor, showing the following:
 - a. Locations and identification of all monitored and controlled electrical equipment.
 - b. **<Insert requirements>.**
3. Control schematic for each device that is controlled by the meters of this Section, including a graphic system schematic representation[, **similar to that indicated on Drawings,**] with device identification.
4. Graphic display for each piece of equipment connected to the electrical monitoring and control system through a data link.
5. Electrical power monitoring and control system network riser diagram that shows schematic layout for entire system including meters, **[gateways] [and] [other network devices]**.

2.7 NETWORK CONFIGURATION SOFTWARE

A. Network Management Graphical Interface Features:

1. Add and remove devices in the power monitoring and control network.
2. Application for naming devices based on a user-defined naming scheme.
3. Add and remove I/O servers in the power monitoring and control network.
4. Edit communication properties for devices including timeouts and delays.
5. Display mandatory fields when adding a new device.

6. Allow to manually connect and disconnect serial, Ethernet, modem, and Ethernet gateway sites.
 7. Enable and disable devices and sites in the power monitoring and control network without interruption to other devices or sites.
 8. Pool modem resources so that the software uses any available modem.
 9. Monitor the following diagnostics:
 - a. Communication request/response and error rates, and timeouts.
 - b. Log acquisition services.
- B. Database Maintenance Features:
1. Backup, archive, and trim data, event, and waveform logs.
 - a. Record start and end date for operation.
 - b. Allow copying data to another database.
 - c. Be capable of selecting any or all of the logs specified for the meters that are Work of this Section.
 - 1) Data logs.
 - 2) Event logs.
 - 3) Waveform logs.
- C. Web Reporter: Allow viewing historical data in preformatted report templates via a web browser.
1. Features:
 - a. User-configurable report generator to trigger on event, based on a schedule, or manual initiation.
 - b. Format reports in HTML, PDF, TIF, Excel, XML, or user-selected printer, or network folder.
 - c. Distribution of reports via email.
 2. Report on power and demand profiles.
 3. Power quality report with CBEMA evaluation.
 4. EN 50160 compliance report.
 5. 100-ms PQ report.
 6. Energy over Period Report:
 - a. User-defined rollup interval by day, week, month, or year.
 - b. Compare daily energy to the following:
 - 1) Previous day.
 - 2) Same day, previous week.
 - 3) Same day, previous month.
 - 4) User-defined specific day.
 - c. Compare weekly energy to the following:
 - 1) Previous week.
 - 2) Same week from previous month.
 - 3) Same week from previous year.
 - 4) User-defined specific week.
 - d. Compare monthly energy to the following:
 - 1) Previous month.
 - 2) Same month from previous year.
 - 3) User-defined specific month.
 - e. Compare annual energy to the following:
 - 1) Previous year.
 - 2) User-defined specific year.

7. Energy by daily period report for the user-defined periods. Aggregate consumption of the periods by the day, week, and year.
8. Tabular Report: Show values for multiple measurements and measurements from multiple devices in tabular format.
9. Trend Report:
 - a. Show values for multiple measurements and measurements from multiple devices in any of the following graphical formats:
 - 1) Line chart.
 - 2) Pie graph.
 - 3) Bar chart.
 - 4) Column chart.
 - 5) Smooth line chart.
 - 6) Stacked column chart.
 - 7) Stacked bar chart.
10. Alarm and Event History: User formatted, based on the meters and priority; and with user-defined alarm and event reports.
11. System Configuration Report:
 - a. Device name.
 - b. Device type.
 - c. Device address.
 - d. Connection status.
 - e. Device protocol.
 - f. Device description.
12. Each default report shall include the following:
 - a. Summary aggregation of data from the selected devices.
 - b. Individual device information.
 - c. Raw data.
13. The reporting tool shall provide a graphical interface to create and manage multiple Time of Use schedules:
 - a. Tariffs including energy cost rates per kWh, kVARh, and kVAh, and demand charges per kW, kVAR, and kVA.
 - b. Off-peak and on-peak times.

2.8 MONITORING AND CONTROL OF POWER DISTRIBUTION EQUIPMENT

- A. Power Distribution Equipment: Web-enabled, direct connected to the LAN or intranet.
- B. Instrument Transformers: Comply with IEEE C57.13.
 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA C12.11 accuracy class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
- C. Ethernet Connectivity:
 1. A multipoint, RS-485 Modbus serial communications network shall be included within the equipment to interconnect breaker trip units, protective relays, drives, and metering devices equipped with communications.
 2. Serial communications network shall be wired to an Ethernet server in the incoming section of the equipment. Hardware and cabling required for the connection to the network shall be included within the power distribution equipment.

3. Serial communications devices within the equipment shall be factory addressed and tested to verify reliable communications to the equipment's Ethernet Server.

D. Ethernet Gateways:

1. User configurable; complying with UL 60950-1, and IEEE 802.3, Class 3 PoE.
2. Include provisions to set initial Ethernet parameters via a local operator interface, or standard (RJ-45) Ethernet port, that is accessible from the front of the equipment. Initial setup shall be limited to basic Ethernet addressing parameters, as assigned by Owner.
3. Common Gateway Features:
 - a. User configurable, with secure password-protected login process.
 - b. Include communications diagnostic information for serial and Ethernet ports as well as internal health status and memory management information through embedded HTML web pages for viewing using a standard web browser.
 - c. Include embedded HTML pages providing real-time information from devices connected to the Ethernet gateway's RS-485 port(s) through a standard web browser.
 - d. Allow firmware upgrades through the communications port.
4. Include a "Quick-Start" guide with the equipment to describe the commissioning process for setting the equipment's Ethernet network address and for ensuring trouble-free data access from any PC on the network, using a standard web browser.
5. Implement a common user interface ("look and feel") across all styles of power equipment.

E. Distribution Equipment Monitoring:

1. Main menu and summary pages, factory configured, to display data for each communicating device within the power equipment lineup.
2. Display Data:
 - a. Circuit summary page to display circuit name, three-phase average rms current, real power (kW), power factor, and breaker status (if applicable).
 - b. Load current summary page to display circuit name, and phase a, b, and c rms current values.
 - c. Demand current summary page to display circuit name, and phase a, b, and c average demand current values.
 - d. Power summary page to display circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
 - e. Energy summary page to display circuit name, real energy (kWh), reactive energy (kVARh), and time/date of last reset.
 - f. For unit substations equipped with dry-type transformer(s) and microbased temperature controller(s), the circuit summary web page listed above shall be augmented with transformer coil temperatures, phase a, b and c current values, and cooling fan status (on/off).
 - g. For motor-control centers, the circuit summary web page shall be tailored specifically for this application, to display circuit name, three-phase average rms current, thermal capacity (percentage), drive output frequency (in Hertz, where applicable), and contactor status.

2.9 SYSTEM OPERATOR INTERFACES

A. Operator means of system access shall be through the following:

1. Desktop workstation with hardwired connection through LAN port.
2. Portable terminal with hardwired connection through LAN port at each meter.

3. Remote connection using outside of system PC, tablet, or phone using an internet portal.

2.10 DESKTOP WORKSTATIONS

- A. Products: Subject to compliance with requirements, **[provide the following]** **[provide one of the following]** **[available products that may be incorporated into the Work include, but are not limited to, the following]**:
 1. Dell Inc.; Precision T-series.
 2. HP; HP Z Workstation.
 3. Lenovo; ThinkStation P Series.
 4. Insert manufacturer's name; insert product designation.
- B. Performance Requirements:
 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. Capable of running **[Microsoft Windows]** **<Insert operating system name>**.
 3. ENERGY STAR compliant.
- C. Personal Computer:
 1. Minimum Processor Speed: **<Insert gigahertz>**, **[Core i3]** **[Core i5]** **[Core i7]**.
 2. RAM:
 - a. Capacity: **[2]** **[4]** **[8]** **<Insert value>** **[GB]**.
 - b. Speed and Type: **[1333]** **<Insert value>** **MHz**, **<Insert type>**.
 3. Primary Hard Drive:
 - a. Media: **[Solid state]** **[Rotating disc, nominal rotational speed of 7200 rpm]** **[Hybrid solid-state and rotating disc]**.
 - b. Number of Hard Drives: One Two Insert number.
 - c. Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - e. Cache Buffer Size: **<Insert number and measurement unit>**.
 - f. **<Insert requirements>**.
 4. Second Hard Drive:
 - a. Media: **[Solid state]** **[Rotating disc, nominal rotational speed of 7200 rpm]** **[Hybrid solid-state and rotating disc]**.
 - b. Capacity: **<Insert number and measurement unit>**.
 - c. Minimum Average Seek Time: **<Insert number and measurement unit>**.
 - d. Cache Buffer Size: **<Insert number and measurement unit>**.
 - e. **<Insert requirements>**.
 5. Optical Drive:
 - a. Type: **<Insert type>**.
 - b. Minimum Average Access Time: **<Insert number>** **ms**.
 - c. Data Transfer Speed: **<Insert number>** **[MB]** **[TB]/s**.
 - d. Reading Formats: Data, audio, recordable, **<Insert other>** and rewritable.
 6. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: **<Insert type>**.
 - c. Minimum Data Buffer Capacity: **<Insert number and measurement unit>**.
 - d. Minimum Average Access Time: **<Insert number>** **ms**.
 - e. Nominal Data Transfer Rates:
 - 1) Reading: **<Insert number>** **[MB]** **[TB]/s**.

- 2) Writing: <Insert number> [MB] [TB]/s.
 - f. Average access time of 150 ms or less.
 - g. MTBF of at least 100,000 power-on hours.
 7. Expansion Slots: Minimum of 4, [32] [64] <Insert number> bit.
 8. Video Card:
 - a. Capable of supporting [one] [two] [three] [four] monitors.
 - b. Resolution: [1920 by 1200] <Insert values> pixels minimum for each monitor.
 - c. RAM: Insert number GB TB.
 - d. Controller Speed: <Insert number> [MHz] [GHz].
 - e. On-Board Memory Speed: <Insert number> [MHz] [GHz].
 - f. On-Board Memory Data Width: <Insert number> bit.
 9. Sound Card:
 - a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
 10. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 11. Wireless Ethernet, 802.11 a/b/g/n.
 12. Optical Modem: Full duplex link for connection to optical fiber cable provided.
 13. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One RJ-45.
 - f. One stereo line-in and line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
 14. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.
- D. Keyboard:
1. 101-key enhanced keyboard.
 2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 3. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- E. Pointing Device:
1. Either a two- or three-button mouse.
 2. Wireless operation within up to 72 inches (1800 mm) in front of workstation.
- F. Flat Panel Display Monitor:
1. Number of Displays: One Two Insert number.

- a. Display Support: **[Individual tilt adjustable base.] [Desk mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.] [Wall mounted, adjustable bracket capable of supporting number of monitors specified above with integral power and display cable organization.] <Insert description.>**
 2. Color display with <Insert inches (mm)> diagonal viewable area.
 3. Aspect Ratio: **[16 to 9] <Insert value>.**
 4. Resolution: 1920 by 1080 Insert value pixels at 60 Hz with pixel size of 0.277 Insert number mm or smaller.
 5. **[Digital] [or] [analog]** input signal.
 6. Response Time: <Insert number> ms.
 7. Dynamic Contrast Ratio: **[50000 to 1] <Insert ratio>.**
 8. Brightness: **[250 cd/sq. m] <Insert value>.**
 9. ENERGY STAR compliant.
 10. Antiglare display.
 - G. Speakers:
 1. Two, with individual controls for volume, bass, and treble.
 2. Signal to Noise Ratio: At least 65 dB.
 3. Power: At least 4 W per speaker/channel.
 4. Magnetic shielding to prevent distortion on the video monitor.
 - H. I/O Cabling: Include applicable cabling to connect I/O devices.
 - I. Software:
 1. Factory-installed operating system.
- 2.11 PORTABLE WORKSTATIONS
- A. Products: Subject to compliance with requirements, **[provide the following] [provide one of the following] [available products that may be incorporated into the Work include, but are not limited to, the following]:**
 1. Dell Inc.; Latitude
 2. Insert manufacturer's name; insert product designation.
 - B. Performance Requirements:
 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
 2. ENERGY STAR compliant.
 3. Hardware and software shall support local downloading to DDC controllers.
 4. Data transfer rate to DDC controller shall be at network speed.
 - C. Processor:
 1. Minimum Processor Speed: <Insert gigahertz>.
 2. RAM:
 - a. Capacity: Insert value GB TB.
 - b. Speed and Type: <Insert value> MHz, <Insert type>.
 3. Hard Drive:
 - a. Media: **[Solid state] [Rotating disc, nominal rotational speed of 7200 rpm] [Hybrid solid-state and rotating disc].**
 - b. Number of Hard Drives: One Two Insert number.

- c. Capacity: <Insert number and measurement unit>.
 - d. Minimum Average Seek Time: <Insert number and measurement unit>.
 - e. Cache Buffer Size: <Insert number and measurement unit>.
 - f. <Insert requirements>.
- 4. Video Card: <Insert number and measurement unit> of RAM.
- D. Input and Output Ports:
 - 1. Serial port.
 - 2. Shared port for external keyboard or mouse.
 - 3. Four USB 3.0 ports.
 - 4. Ethernet port.
 - 5. HDMI port.
 - 6. IEEE 1394 port.
- E. Battery:
 - 1. Capable of supporting operation of portable workstation for a minimum of [8] <Insert number> hours.
 - 2. Battery life of at least three years.
 - 3. Battery charge time of less than three hours.
 - 4. Spare Batteries: One Two.
- F. Keyboard:
 - 1. 85-key [**backlit**] keyboard.
 - 2. Full upper- and lowercase ASCII keyset.
- G. Integral Pointing Device: Touchpad with two buttons. Gesture enabled.
- H. Display:
 - 1. <Insert inches (mm)> diagonal or larger high-definition WLED color display.
 - 2. Antiglare screen.
 - 3. [1920 by 1080] <Insert value> pixel resolution.
 - 4. Brightness: 300 nits.
- I. Network Interfaces
 - 1. Network Interface Card: Include card with connection, as application.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 - 2. Wireless:
 - a. Internal with integrated antenna, capable of supporting 802.11 a/b/g/n.
- J. Digital Video Disc Rewrite Recorder (DVD+/-RW):
 - 1. Compatible with DVD disks and data, audio, recordable and rewritable compact disks.
 - 2. Nominal Data Transfer Rates:
 - a. Reading: <Insert number> [MB] [TB]/s.
 - b. Writing: <Insert number> [MB] [TB]/s.
 - 3. 160-ms access time.
- K. Accessories:
 - 1. Nylon carrying case.
 - 2. Docking station.
 - 3. Mobile broadband card.

4. Wireless optical mouse.
5. <Insert value> [GB] [TB] portable hard drive.
6. Light-sensitive web cam and noise-cancelling digital array microphone.
7. Category 6a patch cable. Minimum cable length shall be <Insert length>.
8. HDMI cable. Minimum cable length shall be <Insert length>.

2.12 RACEWAYS AND BOXES

- A. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
- B. Comply with requirements in Section 27 0528 "Pathways for Communications Systems" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.

2.13 WIRES AND CABLES

- A. Electrical Power Wiring: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 1. Copper conductors are Type THHN/THWN-2.
- B. Control Wiring: Comply with requirements in Section 26 0523 "Control-Voltage Electrical Power Cables."
 1. Optical-Fiber Cable: Multimode, 50/125-micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.
 2. Balanced Twisted Pair Cable: 100-ohm, four-pair Category 5e Category 6.
 3. Workstation Outlets: Four-port-connector assemblies mounted in single or multigang faceplate. Coordinate color and labels with Section 26 2726 "Wiring Devices."
 4. RS-485 Cable: Paired, one pair two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 5. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
 - a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 - b. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
 - c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.
- C. RS-232 Cable:
 1. PVC-Jacketed, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - a. Type CM.
 - b. Flame Resistance: UL 1581, vertical tray.
 2. Plenum-Type, RS-232 Cable: Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - a. Type CMP.
 - b. Flame Resistance: NFPA 262, flame test.

2.14 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, **[provide products by the following]** **[provide products by one of the following]** **[available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:**
- B. Basis-of-Design Product: Subject to compliance with requirements, provide **[product indicated on Drawings]** **<Insert manufacturer's name; product name or designation>** or comparable product by one of the following:
1. ABB France.
 2. Advanced Protection Technologies Inc. (APT).
 3. ALLTEC.
 4. Eaton.
 5. Emerson Electric Co.
 6. GE Zenith Controls.
 7. LEA International.
 8. Leviton Manufacturing Co., Inc.
 9. Mersen USA.
 10. PowerLogics, Inc./PQ Protection.
 11. Schneider Electric USA, Inc.
 12. Siemens Industry, Inc.
 13. Insert manufacturer's name.
- C. SPDs: Comply with UL 1449, Type 1 Type 2.
1. Include LED indicator lights for power and protection status.
 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. **[Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.]**
- D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA Insert value. The peak surge current rating shall be the arithmetic sum of the ratings of the individual metal-oxide varistors in a given mode.
- E. Comply with UL 1283.
- F. Protection modes and UL 1449 SPD for grounded wye circuits with 480Y/277 V 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. L-N: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
 2. L-G: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
 3. N-G: 1200 V for 480Y/277 V 700 V for 208Y/120 V.
 4. L-L: 2000 V for 480Y/277 V 1200 V for 208Y/120 V.
- G. Protection modes and UL 1449 SPD for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
1. L-N: 700 V.
 2. L-G: 700 V.
 3. N-G: 700 V.

- 4. L-L: 1200 V.
- H. SCCR: Equal or exceed 100 200 Insert value kA.
- I. Nominal Rating: 20 10 kA.
- J. Indoor Enclosures: NEMA 250, Type 1.
- K. Outdoor Enclosures: NEMA 250, Type 3R Type 4 Type 4X.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Wiring and Cabling Installation:
 - 1. Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
 - 2. Comply with Section 26 0523 "Control-Voltage Electrical Power Cables" for control wiring.
- E. Raceways Installation:
 - 1. Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
 - 2. Comply with Section 27 0528 "Pathways for Communications Systems" for control wiring, RS-232 cable, and NFPA 70 Class 2 remote-control and signaling circuits.
- F. Identification Installation:
 - 1. Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
 - 2. Comply with Section 27 1513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for twisted pair cable, RS-485 cable, low-voltage control cable, and RS-232 cable.

3. Comply with Section 27 1523 "Communications Optical Fiber Horizontal Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.3 WORKSTATION INSTALLATION

- A. Desktop Workstations Installation:
 1. Install workstation(s) at location(s) directed by Owner.
 2. Install multiple-receptacle power strip with cord for use in connecting multiple workstation components to a single, duplex electrical power receptacle.
 3. Install software on workstation(s) and verify that software functions properly.
 4. Develop Project-specific graphics, trends, reports, logs, and historical database.
 5. Power workstation through a UPS unit. Locate UPS adjacent to workstation.
- B. Portable Workstations Installation:
 1. Turn over portable workstations to Owner at Substantial Completion.
 2. Install software on workstation(s) and verify that software functions properly.
- C. Graphics Application:
 1. Use system schematics indicated as starting point to create graphics.
 2. Develop Project-specific library of symbols for representing system equipment and products.
 3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
 4. Submit sketch of graphic layout with description of all text for each graphic for Owner's[and Architect's] review before creating graphic using graphics software.
 5. Seek Owner input in graphics development once using graphics software.
 6. Final editing shall be done on-site with Owner's review and feedback.
 7. Refine graphics as necessary for Owner acceptance.
 8. On receiving Owner acceptance, print a hard copy to include in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of the system operation and maintenance manual.

3.4 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.5 GROUNDING

- A. For data communication wiring, comply with NECA/BICSI 568.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage]** **[Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 2. Visually inspect balanced twisted pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 4. Test balanced twisted pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
 5. Optical-Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.
 - 2) Attenuation test results for links shall be less than **[2.0 dB] [that calculated according to equation in TIA-568-C.0]**.
 - c. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
 6. Power Monitoring and Control System Tests.
 - a. Test Analog Signals:
 - 1) Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2) Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3) Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
 - b. Test Digital Signals:
 - 1) Check digital signals using a jumper wire.
 - 2) Check digital signals using an ohmmeter to test for contact making or breaking.
 - c. I/O Control Loop Tests:
 - 1) Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.

- 2) Test every I/O point throughout its full operating range.
- 3) Test every control loop to verify that operation is stable and accurate.
- 4) Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
- 5) Test and adjust every control loop for proper operation according to sequence of operation.
- 6) Test software and hardware interlocks for proper operation.
- 7) Operate each analog point at the following:
 - a) Upper quarter of range.
 - b) Lower quarter of range.
 - c) At midpoint of range.
- 8) Exercise each binary point.
- 9) For every I/O point in the system, read and record each value at workstation, at controller, and at field instrument simultaneously. Value displayed at workstation and at field instrument shall match.
- 10) Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

D. Wiring and cabling will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 FINAL REVIEW

- A. Submit written request to Architect **[and]** **[Construction Manager]** when the power monitoring and control system is ready for final review. Written request shall state the following:
1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
 2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
 4. The system is complete and ready for final review.
- B. Review by **[Architect]** **[and]** **[Construction Manager]** will be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Final review shall include a demonstration to parties participating in final review.

3.8 MAINTENANCE SERVICE

- A. Beginning at Substantial Completion, maintenance service shall include **[three] [six] [nine] [12]** months' full maintenance by manufacturer's authorized service representative. Include **[quarterly] [semiannual] [annual]** preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.9 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for **[two] <Insert number>** years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within **[two] <Insert number>** years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
1. Upgrade Notice: At least **[30] <Insert number>** days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain the power monitoring and control system.
- B. Extent of Training:
1. Base extent of training on scope and complexity of power monitoring and control system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 3. Minimum Training Requirements:
 - a. Provide no fewer than **[two] <Insert number>** days of training total.
 - b. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.
 - c. Total days of training shall be broken into not more than **[two] [three] [four] <Insert number>** separate training classes.
 - d. Each training class shall be no fewer than **[one] [two] [three] <Insert number>** consecutive day(s).
- C. Attendee Training Manuals:
1. Provide each attendee with a color hard copy of all training materials and visual presentations.
 2. Hard-copy materials shall be organized in a three-ring binder with table of contents and individual divider tabs marked for each logical grouping of subject matter. Organize material to provide space for attendees to take handwritten notes within training manuals.
 3. In addition to hard-copy materials included in training manual, provide each binder with a sleeve or pocket that includes a DVD or flash drive with PDF copy of all hard-copy materials.

- D. Instructor Requirements:
1. One or multiple qualified instructors, as required, to provide training.
 2. Instructors shall have no fewer than **[five]** <Insert number> years of providing instructional training on no fewer than **[five]** <Insert number> past projects with similar electrical monitoring and control system scope and complexity.
- E. Training Outline: Submit training outline for Owner review at least 10 business days before scheduling training. Outline shall include a detailed agenda for each training day that is broken down into each training session that day, training objectives for each training session, and synopses for each lesson planned.
- F. On-Site Training:
1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
 2. Instructor shall provide training materials, projector, and other audiovisual equipment used in training.
 3. Provide as much of training located on-site as deemed feasible and practical by Owner.
 4. On-site training shall include regular walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
 5. The workstation provided with the system shall be used in training. If workstation is not indicated, provide a temporary workstation to convey training content.
- G. Off-Site Training:
1. Provide conditioned training rooms and workspace with ample tables, chairs, power, and data connectivity for each attendee.
 2. Provide capability to remotely access to Project monitoring and control system for use in training.
 3. Provide a workstation for use by each attendee.
- 3.11 At Completion of Training:
- A. Staff familiar with the system installed are capable of demonstrating operation of the system during final review.
- B. Demonstration shall include, but not be limited to, the following:
1. Accuracy and calibration of 10 I/O points randomly selected by reviewers. If review finds that some I/O points are not properly calibrated and not satisfying performance requirements indicated, additional I/O points may be selected by reviewers until total I/O points being reviewed that satisfy requirements equals quantity indicated.
 2. Reporting of alarm conditions for randomly selected alarms, including different classes of alarms, to ensure that alarms are properly received by operators and workstations.
 3. Trends, summaries, logs, and reports set-up for Project.
 4. Software's ability to communicate with controllers, workstations, and uploading and downloading of control programs.
 5. Software's ability to edit control programs off-line.
 6. Data entry to show Project-specific customizing capability including parameter changes.
 7. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 8. Execution of digital and analog commands in graphic mode.

9. Spreadsheet and curve plot software and its integration with database.
10. Online user guide and help functions.
11. For Each Meter:
 - a. Memory: Programmed data, parameters, trend, and alarm history collected during normal operation is not lost during power failure.
 - b. Operator Interface: Ability to connect directly to each meter with a portable workstation.
 - c. Wiring Labels: Match control drawings.
 - d. Network Communication: Ability to locate a meter on the network. Communication architecture matches Shop Drawings.
 - e. Nameplates and Tags: Accurate and permanently attached to control panel doors, instrument, actuators, and devices.
12. For Each Workstation:
 - a. I/O point lists agree with naming conventions.
 - b. Graphics are complete.
 - c. UPS unit, if applicable, operates.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 ACTION SUBMITALLS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring, all devices and equipment shown on reflected ceiling plans, drawn to scale.
 - 3. Include diagrams for power, signal, and control wiring.

1.2 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and elevations, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which equipment will be attached.
 - 3. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Control modules.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's warranties.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: [On USB media] [On manufacturer's website]. Provide names, versions, and website addresses for locations of installed software.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.4 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Provide products compatible with system specified in Section 26 0943 "Network Lighting Controls".

2.2 ELECTRONIC TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Invensys Controls.
 4. Leviton Manufacturing Co., Inc.
 5. NSi Industries LLC.
 6. TE Connectivity Ltd.
- B. Electronic Time Switches: Solid state, programmable, with alphanumeric display; complying with UL 917.
 1. Listed and labeled as defined in NFPA 70 and marked for intended location and application.
 2. Contact Configuration: SPST DPST DPDT.
 3. Contact Rating: 30-A inductive or resistive, 240-V ac 20-A ballast load, 120-/240-V ac Insert rating.
 4. Programs: Eight on-off set points on a 24-hour schedule[**and an annual holiday schedule that overrides the weekly operation on holidays**].
 5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program[**on selected channels**].
 6. Astronomic Time: All Selected channels.
 7. Automatic daylight savings time changeover.
 8. Battery Backup: Not less than seven days reserve, to maintain schedules and time clock.

2.3 ELECTROMECHANICAL DIAL-TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Invensys Controls.
 4. Leviton Manufacturing Co., Inc.
 5. NSi Industries LLC.
 6. TE Connectivity Ltd.
- B. Electromechanical-Dial Time Switches: Comply with UL 917.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Contact Configuration: SPST DPST SPDT DPDT Insert configuration.
3. Contact Rating: 30-A inductive or resistive, 240-V ac 20-A ballast load, 120-/240-V ac.
4. Circuitry: Allows connection of a photoelectric relay as a substitute for the on-off function of a program.
5. Astronomic time dial.
6. Eight-Day Program: Uniquely programmable for each weekday and holidays.
7. Skip-a-day mode.
8. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of [16] <Insert number> hours.

2.4 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, FLEXIBLE MOUNTING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. NSi Industries LLC.
 5. TE Connectivity Ltd.
- B. Description: Solid state, with SPST DPST Insert configuration dry contacts rated for 1000 W incandescent or 1800 VA inductive Insert value, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A, and compatible with ballasts and LED lamps.
 1. Listed and labeled as defined in NFPA 70, by a agency NRTL, and marked for intended location and application.
 2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range[, and a directional lens in front of the photocell to prevent fixed light sources from causing turn-off].
 3. Time Delay: Fifteen-second minimum, to prevent false operation.
 4. Surge Protection: Metal-oxide varistor.
 5. Mounting: Twist lock complies with ANSI C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure[from same source and manufacturer as switch].
 6. Failure Mode: Luminaire stays ON.

2.5 OUTDOOR PHOTOELECTRIC SWITCHES, SOLID STATE, LUMINAIRE-MOUNTED

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. NSi Industries LLC.
 5. TE Connectivity Ltd.
- B. Description: Solid state, with SPST DPST dry contacts rated for 1000 W incandescent or 1800 VA inductive, to operate connected load, complying with UL 773, and compatible with CFL and LED lamps.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range.
3. Time Delay: Thirty-second minimum, to prevent false operation.
4. Lightning Arrester: Air-gap type.
5. Mounting: Twist lock complying with ANSI C136.10, with base[**from same source and manufacturer as switch**].
6. Failure Mode: Luminaire stays ON.

2.6 OUTDOOR PHOTOELECTRIC SWITCHES, LOW VOLTAGE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Intermatic, Inc.
 3. Leviton Manufacturing Co., Inc.
 4. NSi Industries LLC.
 5. TE Connectivity Ltd.
- B. Description: Solid state; one set of NO dry contacts rated for 24 V dc at 1 A 24 V ac at 1 A, to operate connected load, complying with UL 773, and compatible with luminaire power pack lighting control panelboard.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lux), with an adjustment for turn-on and turn-off levels within that range.
 3. Time Delay: Thirty-second minimum, to prevent false operation.
 4. Mounting: 1/2-inch (13-mm) threaded male conduit.
 5. Failure Mode: Luminaire stays ON.
 6. Power Pack: Dry contacts rated for 20-A Insert value ballast or LED load at 120- and 277-V ac, for 13-A Insert value tungsten at 120-V ac, and for 1 hp Insert value at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 - a. LED status lights to indicate load status.
 - b. Plenum rated.
 7. Power Pack: Digital controller capable of accepting three four Insert number RJ45 inputs with one two outputs rated for 20-A Insert value incandescent or LED load at 120- and 277-V ac, for 16-A Insert value ballast LED at 120- and 277-V ac, and for 1 hp Insert value at 120-V ac. Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.
 - a. With integral current monitoring.
 - b. Compatible with digital addressable lighting interface.
 - c. Plenum rated.

2.7 DAYLIGHT-HARVESTING SWITCHING CONTROLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper Industries, Inc.
 2. Eaton.
 3. Hubbell Building Automation, Inc.
 4. Leviton Manufacturing Co., Inc.

5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. Sensor Switch, Inc.
8. TE Connectivity Ltd.
9. WattStopper; a Legrand? Group brand.

B. Description: System operates indoor lighting.

C. Sequence of Operation: As daylight increases, the lights are turned off at a predetermined level. As daylight decreases, the lights are turned on at a predetermined level.

1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present.
 - b. When significant daylight is present (target level).
 - c. System programming is done with two hand-held, remote-control tools.

D. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, with [integrated] power pack, that detects changes in indoor lighting levels that are perceived by the eye.

E. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
3. Sensor Output: Digital signal compatible with power pack.
4. Sensor type: Open loop Closed loop.
5. Zone: Single Multi.
6. Power Pack: Dry contacts rated for 20-A Insert value ballast or LED load at 120- and 277-V ac, for 13-A Insert value tungsten at 120-V ac, and for 1 hp Insert value at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 - a. LED status lights to indicate load status.
 - b. Plenum rated.
7. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lux), with an adjustment for turn-on and turn-off levels within that range.
8. Atrium Space Sensors Light-Level Monitoring Range: 100 to 1000 fc (1080 to 10 800 lux), with an adjustment for turn-on and turn-off levels within that range.
9. Skylight Sensors Light-Level Monitoring Range: 1000 to 10,000 fc (10 800 to 108 000 lux), with an adjustment for turn-on and turn-off levels within that range.
10. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
11. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
12. Test Mode: User selectable, overriding programmed time delay to allow settings check.
13. Control Load Status: User selectable to confirm that load wiring is correct.
14. Indicator: Two digital displays to indicate the beginning of on-off cycles.

2.8 DAYLIGHT-HARVESTING DIMMING CONTROLS, ANALOG

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Cooper Industries, Inc.
2. Deep Roof Lighting.
3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.

5. Lithonia Lighting; Acuity Brands Lighting, Inc.
 6. WattStopper; a Legrand? Group brand.
- B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
 2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.
- C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated separate power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.
- D. Electrical Components, Devices, and Accessories:
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
 3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).
- E. Power Pack: Dry contacts rated for 20-A Insert value ballast or LED load at 120- and 277-V ac, for 13-A Insert value tungsten at 120-V ac, and for 1 hp Insert value at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
1. LED status lights to indicate load status.
 2. Plenum rated.
- 2.9 DAYLIGHT-HARVESTING DIMMING CONTROLS, DIGITAL
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Industries, Inc.
 2. Deep Roof Lighting.
 3. Hubbell Building Automation, Inc.
 4. Leviton Manufacturing Co., Inc.
 5. Lithonia Lighting; Acuity Brands Lighting, Inc.
 6. WattStopper; a Legrand? Group brand.
- B. Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, lights are dimmed.
1. Lighting control set point is based on the following two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
 2. System programming is done with two hand-held, remote-control tools.
 - a. Initial setup tool.
 - b. Tool for occupants to adjust the target levels by increasing the set point up to 25 percent, or by minimizing the electric lighting level.

- C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with integrated separate power pack mounted on luminaire, to detect changes in indoor lighting levels that are perceived by the eye.
- D. Electrical Components, Devices, and Accessories:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Sensor Output: 0- to 10-V dc to operate luminaires. Sensor is powered by controller unit.
 - 3. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).
- E. Power Pack: Digital controller capable of accepting three four Insert number RJ45 inputs with one two output(s) rated for 20-A Insert value incandescent [**or**] [**LED**] load at 120- and 277-V ac, for 13-A 16-A Insert value at 120- and 277-V ac, and for 1 hp Insert value at 120-V ac. Sensor has 24-V dc Class 2 power source, as defined by NFPA 70.
 - 1. With integral current monitoring.
 - 2. Compatible with digital addressable lighting interface.
 - 3. Plenum rated.

2.10 INDOOR OCCUPANCY AND VACANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bryant Electric.
 - 2. Cooper Industries, Inc.
 - 3. Hubbell Building Automation, Inc.
 - 4. Intermatic, Inc.
 - 5. Leviton Manufacturing Co., Inc.
 - 6. Lithonia Lighting; Acuity Brands Lighting, Inc.
 - 7. Lutron Electronics Co., Inc.
 - 8. NSi Industries LLC.
 - 9. Philips Lighting Controls.
 - 10. RAB Lighting.
 - 11. Sensor Switch, Inc.
 - 12. Square D.
 - 13. WattStopper; a Legrand? Group brand.
- B. General Requirements for Sensors:
 - 1. Wall Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
 - 2. Passive infrared Ultrasonic Dual technology.
 - 3. Integrated Separate power pack.
 - 4. Hardwired Wireless connection to switch and BAS ; and BAS and lighting control system.
 - 5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 6. Operation:
 - a. Occupancy Sensor: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 - 7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A Sensor is powered from the power pack Wireless.

8. Power: Line voltage Integral photovoltaic collector.
 9. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 10. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 12. Bypass Switch: Override the "on" function in case of sensor failure.
 13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.
- C. PIR Type: Wall Ceiling mounted; detect occupants in coverage area by their heat and movement.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room, Ceiling Mounted): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
- D. Ultrasonic Type: Wall Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
 6. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters) 2000 square feet (220 square meters) 3000 square feet (330 square meters) when mounted 84 inches (2100 mm) above finished floor.
- E. Dual-Technology Type: Wall Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 1000 square feet (110 square meters) 2000 square feet (220 square meters) 3000 square feet (330 square meters) when mounted 48 inches (1200 mm) above finished floor.

2.11 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Bryant Electric.
 2. Cooper Industries, Inc.
 3. Hubbell Building Automation, Inc.
 4. Intermatic, Inc.
 5. Leviton Manufacturing Co., Inc.
 6. Lithonia Lighting; Acuity Brands Lighting, Inc.
 7. Lutron Electronics Co., Inc.
 8. NSi Industries LLC.
 9. Philips Lighting Controls.
 10. RAB Lighting.
 11. Sensor Switch, Inc.
 12. Square D.
 13. WattStopper.
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection using wireless connection.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application[, and shall comply with California Title 24].
 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
 4. Switch Rating: Not less than 800-VA ballast or LED load at 120 V, 1200-VA ballast or LED load at 277 V, and 800-W incandescent.
- C. Wall-Switch Sensor Tag OS:
 1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m) 2100 sq. ft (196 sq. m).
 2. Sensing Technology: PIR Dual technology - PIR and ultrasonic.
 3. Switch Type: SP. SP, dual circuit. SP, manual "on," automatic "off." SP, field-selectable automatic "on," or manual "on," automatic "off."
 4. Capable of controlling load in three-way application.
 5. Voltage: Match the circuit voltage 120 V 277 V Dual voltage - 120 and 277 V.
 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
 9. Color: White Black Insert color.
 10. Faceplate: Color matched to switch.

- D. Wall-Switch Sensor Tag OSD:
 - 1. Same as type OS except with 0-10V dimming capability.

2.12 DIGITAL TIMER LIGHT SWITCH

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Industries, Inc.
 - 2. Intermatic, Inc.
 - 3. Invensys Controls.
 - 4. Leviton Manufacturing Co., Inc.
 - 5. NSi Industries LLC.
 - 6. TE Connectivity Ltd.
- B. Description: Combination digital timer and conventional switch lighting control unit. Switchbox-mounted, backlit LCD display, with selectable time interval in 10 20 minute increments.
 - 1. Rated 960 W at 120 V ac for tungsten lighting, 10 A at 120 V ac or 10 A at 277 V ac for fluorescent or LED lighting, and 1/4 hp at 120 V ac.
 - 2. Standards: Comply with UL 20.
 - 3. Integral relay for connection to BAS.
 - 4. Voltage: Match the circuit voltage 120 V 277 V Dual voltage - 120 and 277 V.
 - 5. Color: White Black Insert color.
 - 6. Faceplate: Color matched to switch.

2.13 HIGH-BAY OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Building Automation, Inc.
- B. Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Operation: Turn lights on when coverage area is occupied, and to half-power when unoccupied; with a time delay for turning lights to half-power that is adjustable over a minimum range of 1 to 16 minutes.
 - 3. Continuous Lamp Monitoring: When lamps are dimmed continuously for 24 hours, automatically turn lamps on to full power for 15 minutes for every 24 hours of continuous dimming.
 - 4. Power: Line voltage.
 - 5. Operating Ambient Conditions: 32 to 149 deg F (0 to 65 deg C).
 - 6. Mounting: Threaded pipe.
 - 7. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 8. Detector Technology: PIR.
 - 9. Power and dimming control from the luminaire ballast that has been modified to include the dimming capacitor[**and MyzerPORT option**].

- C. Detector Coverage: User selectable by interchangeable PIR lenses, suitable for mounting heights from 12 to 50 feet (3.7 to 15.2 m).
- D. Accessories: Obtain manufacturer's installation and maintenance kit with laser alignment tool for sensor positioning and power port connectors.

2.14 EXTREME-TEMPERATURE OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Industries, Inc.
 - 2. Sensor Switch, Inc.
- B. Description: Ceiling-mounted, solid-state, extreme-temperature occupancy sensors with a separate power pack.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended application in damp locations.
 - 2. Operation: Turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes.
 - 3. Operating Ambient Conditions: From minus 40 to plus 125 deg F (minus 40 to plus 52 deg C).
 - 4. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 - 5. Power Pack: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 - 6. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind cover.
 - 7. Bypass Switch: Override the "on" function in case of sensor failure.
 - 8. Automatic Light-Level Sensor: Adjustable from 2 to 10 fc (21.5 to 108 lux); keep lighting off when selected lighting level is present.
- C. Detector Technology: PIR. Ceiling mounted; detect occupants in coverage area by their heat and movement.
 - 1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 - 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1500 sq. ft. (139 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - 3. Detection Coverage (High Bay): Detect occupancy within 25 feet (7.6 m) when mounted on a 25-foot- (7.6-m-) high ceiling.

2.15 OUTDOOR MOTION SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bryant Electric.
 - 2. Cooper Industries, Inc.

3. Hubbell Building Automation, Inc.
4. Leviton Manufacturing Co., Inc.
5. Lithonia Lighting; Acuity Brands Lighting, Inc.
6. NSi Industries LLC.
7. RAB Lighting.
8. Sensor Switch, Inc.
9. WattStopper; a Legrand? Group brand.

B. Description: Solid-state outdoor motion sensors.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application[, and shall comply with California Title 24].
2. **[PIR] [Dual-technology (PIR and ultrasonic)]** type, weatherproof. Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm). Comply with UL 773A.
3. Switch Rating:
 - a. Luminaire-Mounted Sensor: 1000-W incandescent, 500-VA fluorescent/LED Insert rating.
 - b. Separately Mounted Sensor: Dry contacts rated for 20-A ballast or LED load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
4. Switch Type: SP. SP, dual circuit. SP, manual "on," automatic "off." SP, field-selectable automatic "on," or manual "on," automatic "off." With bypass switch to override the "on" function in case of sensor failure.
5. Voltage: Match the circuit voltage 120-V 277-V Dual voltage, 120- and 277-V type.
6. Detector Coverage:
 - a. Standard Range: 210-degree field of view, with a minimum coverage area of 900 sq. ft. (84 sq. m).
 - b. Long Range: 180-degree field of view and 110-foot (34-m) detection range.
7. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
8. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
9. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
10. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and help eliminate false "off" switching.
11. Operating Ambient Conditions: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F (minus 40 to plus 54 deg C), rated as "raintight" according to UL 773A.

2.16 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. ASCO: a brand of Vertiv.
 3. Eaton.
 4. General Electric Company.
 5. Square D.
- B. Description: Electrically operated and mechanically electrically held, combination-type lighting contactors with fusible switch nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.
 4. Provide with control and pilot devices as **[indicated on Drawings]** **[scheduled]**, matching the NEMA type specified for the enclosure.
- C. Interface with DDC System for HVAC: Provide hardware interface to enable the DDC system for HVAC to monitor and control lighting contactors.
1. Monitoring: On-off status, **<Insert monitoring point>**.
 2. Control: On-off operation, **<Insert control point>**.
- 2.17 EMERGENCY LIGHTING CONTROL RELAY
- A. Description: Emergency lighting control relay which bypasses all local dimming/switching controls upon loss of normal power.
1. Voltage: 120V or 277V as required to match circuit voltage.
 2. Dimming: Capable of acceptance 0-10V dimming signal and passing through the signal during normal operation. Relay shall bring the connected light fixtures to full brightness upon loss of normal power.
 3. Current rating: 16A, minimum.
 4. Compatible Load Types: LED.
 5. Status Indicators: LED type, with individual indicators for Normal Power, Test, and Emergency Power.
 6. Test Switch: Visible momentary contact switch.
 7. UL 924 Listed.
- 2.18 BRANCH CIRCUIT EMERGENCY LIGHTING TRANSFER SWITCH
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Bodine.
 2. Hubbell.
 3. ETC.
- B. Description: Emergency lighting transfer device which automatically transfers to an emergency power source upon loss of power and overrides all local dimming/switching controls.
1. Voltage: 120V or 277V.
 2. Current Rating: 16A, minimum.
 3. Compatible Load Types: Incandescent, halogen, magnetic ballasts, electronic ballasts, LED drivers.
 4. Status Indicators: LED type, with individual indicators for Normal Power, Test, and Emergency Power.
 5. Test Switch: Visible momentary contact switch.
 6. UL 1008 Listed.

2.19 MINI EMERGENCY LIGHTING INVERTER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bodine or approved equal.
- B. Description: Emergency lighting inverter with ratings under 1000VA which instantly provides power to the load for 90 minutes upon loss of power.
 - 1. Voltage 120V or 277V
 - 2. Maximum Power Load: 100VA, 250VA, or 400VA as indicated on Drawings. Where ratings are not indicated on Drawings, provide inverter with a rating equal to the connected load plus 20% spare capacity.
 - 3. 0-10VDC dimming output. 250VA unit dimming output shall be automatically controlled in emergency mode as required to prevent overload. 100VA unit shall have DIP switches to allow field adjustment of emergency mode dimming level.
 - 4. Output Waveform: Sinusoidal.
 - 5. Compatible Load Types: Incandescent, halogen, magnetic ballasts, electronic ballasts, LED drivers.
 - 6. Batteries: Sealed lead-calcium.
 - 7. In-rush Current: Shall be capable of withstanding in-rush current of LED drivers in light fixtures indicated to be connected to the inverter.
 - 8. Status Indicators: LED type.
 - 9. Test Switch: Visible momentary contact switch.

2.20 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 No. 22 No. 24 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 No. 16 No. 18 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.3 CONTACTOR INSTALLATION

- A. Comply with NECA 1.
- B. Mount electrically held lighting contactors with elastomeric isolator pads to eliminate structure-borne vibration unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 26 0553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to evaluate lighting control devices and perform tests and inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Lighting control devices will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in other sections.
- B. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 0936 - MODULAR DIMMING CONTROLS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes wall-box, multiscene, modular dimming controls.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - 1. Include elevation views of front panels of control and indicating devices and control stations.
 - 2. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of wall-box multiscene dimming controls that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Cost to repair or replace any parts for **[two]** <Insert number> years from date of Substantial Completion.
 - 2. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for **[eight]** <Insert number> years, that failed in service due to transient voltage surges.

PART 2 - PRODUCTS**2.1 MANUFACTURERS**

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 - 1. Eaton Lighting Solutions

2. Leviton Manufacturing Co., Inc.
3. Lightolier; a Philips group brand.
4. Lithonia Lighting; Acuity Brands Lighting, Inc
5. Lutron Electronics Co., Inc.
6. Philips Lighting Controls.
7. Insert manufacturer's name.

2.2 SYSTEM DESCRIPTION

- A. Compatibility:
 1. Dimming control components shall be compatible with luminaires luminaires and ballasts luminaires, ballasts, and transformers.
 2. Dimming control devices shall be compatible with lighting control system components specified in Section 26 0943.16 "Addressable-Luminaire Lighting Controls" and Section 26 0943.23 "Relay-Based Lighting Controls," and in Section 26 0923 "Lighting Control Devices."
- B. Dimmers and Dimmer Modules: Comply with UL 508.
 1. Audible Noise and RFI Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or RFI. Modules shall include integral or external filters to suppress audible noise and RFI.
 2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.
- C. Capacities: Unit shall be rated for [2400 W at 240-V ac and 2000 W at 120-V ac] <Insert value> for up to [100] <Insert number> devices or zones.
- D. Surge Protection: Withstand supply power surges without impairment to performance.
 1. Panels: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
 2. Other System Devices: 6000 V, 3000 A, complying with IEEE C62.41.1 and IEEE C62.41.2.
- E. Off Control Position: User-selected off position of any control point shall disconnect the load from line supply.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 WALL-BOX MULTISCENE DIMMING CONTROLS

- A. Description: Factory-fabricated equipment providing manual dimming consisting of a wall-box-mounted master controller[**and indicated number of wall-box zone stations**]. Controls and dimmers shall be integrated for mounting in multigang wall box under a single wall plate. Each zone shall be adjustable to indicated number of scenes, which shall reside in the memory of zone controller.
- B. Dimmers: Each zone shall be configurable to control the following loads:
 1. Fluorescent lamps with [**electronic**] [**magnetic**] ballasts.
 2. LED lamps.
 3. Incandescent lamps.
 4. Low-voltage lamps, derived with [**magnetic**] [**electronic**] transformers.

5. Non-dim, on-off switching only.
 6. **<Insert special lighting equipment>.**
- C. Dimmers: Regulate voltages to maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent of rms voltage.
- D. Memory:
1. Retain preset scenes and fade rates through momentary (up to 3-second) power interruptions.
 2. Retain preset scenes through power failures for at least **[seven]** **<Insert number>** days.
- E. Device Plates: Style, material, and color **[shall comply with Section 26 2726 "Wiring Devices."]** **<Insert description.>** Master-control cover plate shall be one piece.
- F. Master controller shall include the following:
1. Cover-mounted switches, including master off, all bright, and selectors for each scene.
 2. Cover-mounted LED indicator lights, one associated with each scene switch, and one for the master off switch.
 3. Concealed switches and indicators for specified function.
 4. A raise/lower switch for each zone for temporary adjustments of the zone without altering scene values stored in memory.
 5. Fade time indicated by digital display for current scene while fading.
 6. Cover-mounted infrared receiver.
- G. Infrared Transmitters: Wireless remote control for recalling **[each]** **[four]** **<Insert number>** of the presets. Operate up to 50 feet (15 m) within line of sight of the master controller.
- 2.4 CONDUCTORS AND CABLES
- A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 No. 22 No. 24 AWG. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Label each dimmer module with a unique designation.
- C. Label each scene control button with approved scene description.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:
 - 1. Continuity tests of circuits.
 - 2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
 - a. Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
- B. Dimming control components will be considered defective if they do not pass tests and inspections.
- C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- D. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.4 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls.[**Laptop portable computer shall be used in training.**]

END OF SECTION

SECTION 26 0943 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes manually operated lighting controls with relays electrically operated circuit breakers and control module.
- B. Section includes manually operated, PC-based, digital lighting controls with external signal source, relays , electrically operated circuit breakers, and control module.
- C. Section includes individually addressable lighting control devices communicating with data-entry and -retrieval devices using DALI protocol.
- D. Related Requirements:
 - 1. Section 26 0923 "Lighting Control Devices" for time clocks, photoelectric sensors, occupancy sensors, and multipole contactors.
 - 2. Section 26 0933 "Central Dimming Controls" or Section 26 0936 "Modular Dimming Controls" for dimming control components.

1.2 DEFINITIONS

- A. BAS: Building automation system.
- B. DALI: Digital addressable lighting interface.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
- D. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- E. PC: Personal computer; sometimes plural as "PCs."
- F. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
- G. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.
- H. UTP: Unshielded twisted pair.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, DALI network materials, manual switches and plates, and conductors and cables.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Electrically Held Relays: Equal to < **Insert number** > percent of amount installed[**for each size indicated**], but no fewer than < **Insert number** > relays.
 2. Electrically Operated, Molded-Case Circuit Breakers: Equal to < **Insert number** > percent of amount installed[**for each size indicated**], but no fewer than < **Insert number** > circuit breakers.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
- E. Comply with NFPA 70.

1.8 COORDINATION

- A. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of lighting control functions.
 - 2. Coordinate lighting controls with BAS HVAC controls. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
 - 3. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
- B. Coordinate lighting control components specified in this Section with components specified in Section 26 2416 "Panelboards."

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of software input/output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Damage of electronic components due to transient voltage surges.
 - d. **<Insert type of failure>.**
 - 2. Warranty Period: [**Two**] **<Insert number>** years from date of Substantial Completion.
 - 3. Extended Warranty Period Failure Due to Transient Voltage Surges: [**Eight**] **<Insert number>** years.
 - 4. Extended Warranty Period for Electrically Held Relays: [**10**] **<Insert number>** years from date of Substantial Completion.

1.10 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for [**two**] **<Insert number>** years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within [**two**] **<Insert number>** years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, [**provide products by one of the following**] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide [**product indicated on Drawings**] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
 1. Acuity Brands Lighting, Inc.; Lithonia Lighting brand.
 2. Intelligent Lighting Controls.
 3. Leviton Mfg. Company Inc.
 4. Lighting Control & Design, Inc.
 5. Lightolier Controls; a division of Genlyte Group, LLC.
 6. Lutron Electronics Co., Inc.
 7. Musco Lighting.
 8. NexLight; part of the Northport Engineering Group.
 9. Square D; a brand of Schneider Electric.
 10. Starfield Controls, Inc.
 11. Touch-Plate Technologies.
 12. Triatek, Inc.
 13. Watt Stopper/Legrand.
 14. <Insert manufacturer's name>.

2.2 SYSTEM REQUIREMENTS

- A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
- B. Performance Requirements: Manual switch operation sends a signal to network-system control module that processes the signal according to its programming and routes an open or close command to one or more relays electrically operated circuit breakers in the power-supply circuits to groups of lighting fixtures or other loads.
- C. Performance Requirements: Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based network-system control module that processes the signal according to its programming and routes an open or close command to one or more relays electrically operated circuit breakers in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.

- D. Performance Requirements: Individually addressable devices (such as electronic ballasts, dimmers, and manual switches) are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs[, and] <Insert other digital communications device>). Devices also report status to data-entry and -retrieval devices through the bus.
- E. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.
 - 1. Hardwired Points:
 - a. Monitoring: On-off status, < Insert monitoring point>.
 - b. Control: On-off operation, < Insert control point>.
 - 2. communication interface with the BAS shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

2.3 CONTROL MODULE

- A. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD or LED shall display menu-assisted programming and control.
- B. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Unit shall be networked for control of indicated number of output circuits. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices, all located in other enclosures. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD shall display manual-control and programming steps. Modules and their associated control panels shall include the following features:
 - 1. Multichannel output with <Insert number> channels.
 - 2. Multiple inputs and multichannel output arranged for <Insert number> channels.
 - 3. Multiple inputs for indicated occupancy sensors and hand-held programming device.
- C. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Control units shall be networked and capable of receiving inputs from indicated sensors and hand-held programmer. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits shall include digital circuits arranged to transmit control commands to remote preset dimmers. Modules and their associated control panels shall include the following features:
 - 1. Multichannel output with <Insert number> channels.
 - 2. Multiple inputs and multichannel output arranged for <Insert number> channels.

3. Multiple inputs for occupancy sensors, daylight sensors, and dimming systems with associated daylight sensors.
- D. Control Module Description: Panelboard mounted; comply with UL 916 (CSA C22.2, No. 205); microprocessor based, solid-state, 365-day timing and control unit. Control units shall be networked and capable of receiving inputs from sensors and other sources. Panelboard shall use low-voltage-controlled, electrically operated, molded-case branch circuit breakers as prime power-circuit switching devices. Circuit breakers and a limited number of digital or analog, low-voltage control-circuit outputs shall be individually controlled by control module. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable. Panelboard shall also comply with Section 26 2416 "Panelboards."
- E. Control Module Description: Comply with UL 508 (CAN/CSA C22.2, No. 14); microprocessor-based, networked, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.
- F. Control Module Description: Programmable, PC-based unit with [**17-inch color video monitor**] [**15-inch color LCD**] and keyboard for graphic display and programming of system status and to override breaker status; and to display status of local override controls and diagnostic information. If the control module is applied to emergency lighting units, control unit shall indicate failure of normal power and that the lighting units are, or are not, powered by the alternate power source.
1. Display: Single graphic display for programming lighting control panelboards.
 2. Display: Separate graphic displays for programming each lighting control panelboard.
 3. Interoperability: Control module shall be configured to connect with other control systems using RS-485 network to enable remote workstations to use control module functions.
 4. Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with DALI-compliant, digital-communication devices. Software shall be written for Windows operating system, with the full suite of DALI commands and device parameter settings.
 5. System Memory: Nonvolatile. System shall reboot program and reset time automatically without errors after power outages up to 90 days' duration.
 6. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.
 7. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.
 8. Astronomic Control: Automatic adjustment of dawn and dusk switching.

9. Demand Control: Demand shall be monitored through pulses from a remote meter and shall be controlled by programmed switching of loads. System capability shall include sliding window averaging and programming of load priorities and characteristics. Minimum of two different time-of-day demand schedules shall execute load-management control actions by switching output circuits or by transmitting other types of load-control signals.
10. Confirmation: Each relay or contactor device operated by system shall have auxiliary contacts that provide a confirmation signal to the system of on or off status of device. On or off status confirmation for each electrically operated circuit breaker shall be provided by an auxiliary contact or by a sensing device at load terminal.
 - a. Software shall interpret status signals, provide for their display, and initiate failure signals.
11. Remote Communication Capability: Allow programming, data-gathering interrogation, status display, and controlled command override from a PC at a remote location over DALI networks. System shall include modem, communications and control software, and remote computer compatibility verification for this purpose.
12. Telephone Override Capability: Override programmed lighting shutdown commands by telephoning computer and entering a voice-menu-guided, override touch-tone code specific to zone being controlled.
13. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.
14. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override. **Comply with provisions in California Code of Regulations, Title 24, Part 6.**
15. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.
16. Programmed time signals shall change preset scenes and dimmer settings.
17. Daylight Balancing Dimming Control: Control module shall interpret variable analog signal from photoelectric sensor and shall route dimming signals to dimming fluorescent ballast control circuits. Signal shall control dimming of fixture so illumination level remains constant as daylight contribution varies.
18. Daylight Compensating Switch Control: Control module shall interpret a preset threshold illumination-level signal from a photoelectric relay and shall activate relays controlling power to selected groups of lighting fixtures to turn them on and off to maintain adjustable minimum illumination level as daylight contribution varies.
19. Energy Conservation: Bilevel control of special ballasts or dimming circuits to comply with local energy codes.
20. Flick Warning: Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval. Warning shall be repeated after a second preset interval before end of programmed override period.
21. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.
22. Additional Programming: In addition to system programming by the PC, individual control modules shall be networked and programmable using data-entry and -retrieval (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs[, and] **<Insert other digital communications device>**).

2.4 POWER DISTRIBUTION COMPONENTS

- A. Modular Relay Panel: Comply with UL 508 (CAN/CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.
 1. Cabinet: Steel with hinged, locking door.
 - a. Barriers separate low-voltage and line-voltage components.
 - b. Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
 - c. Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
 2. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.
 - a. Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.
 - b. Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
 - c. Endurance: 50,000 cycles at rated capacity.
 - d. Mounting: Provision for easy removal and installation in relay cabinet.
- B. Electrically Operated, Molded-Case Circuit-Breaker Panelboard: Comply with NEMA PB 1 and UL 50 (CAN/CSA C22.2, No. 94), UL 67 (CSA C22.2, No. 29), UL 489 (CAN/CSA C22.2, No. 65), and UL 916 (CSA C22.2, No. 205).
 1. Cabinets: In addition to requirements specified below, comply with Section 26 2416 "Panelboards."
 2. Electrically Operated, Molded-Case Circuit Breakers: Bolt-on type.
 - a. Switching Endurance Ratings: Certified by manufacturer or by a nationally recognized testing laboratory (NRTL) for at least 20,000 open and close operations under rated load at 0.8 power factor.
 - b. Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent tungsten filament load.
 - c. Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent fluorescent ballasts rated for 10 percent total harmonic distortion.
 - d. Listed and labeled as complying with UL SWD, HCAR, and HID ratings by an NRTL acceptable to authorities having jurisdiction.
- C. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels.

2.5 DALI NETWORK MATERIALS

- A. Network Power Supply and Router: Interface device connecting TCP/IP control networks to DALI-compliant network.
 1. DALI-Compliant Network Power Rating: [**One full-rated network for**] [**Two full-rated networks, each capable of**] powering up to 64 addressable devices for each network; suitable for use with NFPA 70, Class 1 and Class 2 control circuits; and 16 V dc, 250 mA.
 2. Primary Power: 120 or 277 V, field selectable; 12 VA.
 3. 10basT Ethernet port.

4. LED indicator lights for Ethernet status (link, send, and receive), power-on, and DALI network failure.

B. Lighting Control Software:

1. Five-tier hierarchical architecture; high-speed, parallel query; and distributed-logic processing scalable from single rooms to full campuses.
2. Automatic backup for all settings and parameters.
3. TCP/IP network protocol.
4. Interactive with other building management systems at TCP/IP level.
5. At least three security levels.
6. Support the full suite of DALI commands and device parameter settings.
7. Scheduling modules to provide building-wide scene scheduling.
8. Billing modules to track energy use for multiple tenants and able to produce monthly billing statements.
9. Support load shedding, peak shaving, sweeps with local override, and other energy-conservation measures.
10. Able to report individual device status, including inoperative lamps, ballast failure detection, and dimmer position.

2.6 MANUAL ANALOG SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary-contact, low-voltage type.
 1. Match color specified in Section 26 2726 "Wiring Devices."
 2. Integral green **[LED]** **[neon]** pilot light to indicate when circuit is on.
 3. Internal white **[LED]** **[neon]** locator light to illuminate when circuit is off.
- B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 26 2726 "Wiring Devices."
- C. Wall-Box Dimmers: Comply with Section 26 2726 "Wiring Devices."
- D. Wall Plates: Single and multigang plates as specified in Section 26 2726 "Wiring Devices."
- E. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.7 FIELD-MOUNTED DIGITAL CONTROLS AND PLATES

- A. Connection Type: RS-485 protocol, category 5 5e UTP cable, using RJ45 connectors. Power shall be from the control unit.
- B. Pushbutton Switches: Modular, solid-state, programmable, digital, momentary contact, designed to connect to a microprocessor based control unit as a manual control source.
 1. Mounting: Standard single-gang recessed switchbox, using device plates specified in Section 26 2726 "Wiring Devices."
 2. Multi-Gang Mounting: One to six pushbuttons per gang.

2.8 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

- B. Classes 2 and 3 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. [18] [22] [24] AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. [14] [16] [18] AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Structured Network Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category [5e] [6] for horizontal copper cable and with Section 27 1500 "Communications Horizontal Cabling."
- E. RS-485 Cables:
 - 1. Standard Cable: NFPA 70, Type CM[or CMG].
 - a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.
 - 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. Flame Resistance: NFPA 262, Flame Test.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install wiring in raceways [**except where installed in accessible ceilings**] [**except where installed in accessible ceilings and gypsum board partitions**]. Minimum conduit size shall be 1/2 inch (13 mm).
 - 1. For power wiring comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. For digital data transmission and low-voltage (operating at less than 50 V) remote control and signaling cables, comply with Section 26 0523 "Control-Voltage Electrical Power Cables."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
- D. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- E. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
- G. Identify components and power and control wiring according to Section 26 0553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. Test for circuit continuity.
 - 2. Verify that the control module features are operational.
 - 3. Check operation of local override controls.
 - 4. Test system diagnostics by simulating improper operation of several components selected by Architect.
- E. Lighting controls will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

3.3 SOFTWARE INSTALLATION

- A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.4 ADJUSTING

- A. Occupancy Adjustments: When requested within [12] <Insert number> months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to [two] <Insert number> visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain lighting controls[and software training for PC-based control systems]. See Section 01 7900 "Demonstration and Training."

END OF SECTION

SECTION 26 2213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
 - 1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.
- B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.

- C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.
- D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dongan Electric Manufacturing Company.
 - 2. Eaton.
 - 3. ABB.
 - 4. Hammond Power Solutions Inc.
 - 5. MGM Transformer Company.
 - 6. Siemens Power Transmission & Distribution, Inc.
 - 7. Sola/Hevi-Duty; a brand of Emerson Electric Co.
 - 8. Square D; by Schneider Electric.
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
- D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."
- C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.

2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
 3. Grounded to enclosure.
- D. Coils: Continuous windings without splices except for taps.
1. Coil Material: Copper.
 2. Internal Coil Connections: Brazed or pressure type.
 3. Terminal Connections: Welded.
- E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- F. Enclosure: Ventilated.
1. NEMA 250, Type 2 : Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 3. Wiring Compartment: Sized for conduit entry and wiring installation.
- G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- I. Insulation Class, Smaller Than 30 kVA: 180 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- J. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- K. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- L. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
 2. Indicate value of K-factor on transformer nameplate.
 3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.
- M. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- N. Wall Brackets: Manufacturer's standard brackets.
- O. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
1. 9.00 kVA and Less: 40 dBA.
 2. 9.01 to 30.00 kVA: 45 dBA.

3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9.
4. 50.01 to 150.00 kVA: 50 dBA for K-factors of 1, 4, and 9.
5. 150.01 to 300.00 kVA: 55 dBA for K-factors of 1, 4, and 9.
6. 300.01 to 500.00 kVA: 60 dBA for K-factors of 1, 4, and 9.
7. 500.01 to 700.00: 62 dBA for K-factors of 1, 4, and 9.
8. 700.01 to 1000.00: 64 dBA for K-factors of 1, 4, and 9.
9. 1000.01 to 1500.00 kVA: .

2.4 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 0553 "Identification for Electrical Systems."
- B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 26 0553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
 1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
 2. Ratio tests at rated voltage connections and at all tap connections.
 3. Phase relation and polarity tests at rated voltage connections.
 4. No load losses, and excitation current and rated voltage at rated voltage connections.
 5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
 6. Applied and induced tensile tests.
 7. Regulation and efficiency at rated load and voltage.
 8. Insulation-Resistance Tests:
 - a. High-voltage to ground.
 - b. Low-voltage to ground.
 - c. High-voltage to low-voltage.
 9. Temperature tests.
- B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

- D. Verify that ground connections are in place and requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
 - 2. Brace wall-mounted transformers as specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Division 03 and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 26 0529 "Hangers and Supports for Electrical Systems."
 - 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative.
- E. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 - 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- F. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 - 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.

- b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
- c. Perform power-factor or dissipation-factor tests on all windings.
- d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
- e. Perform an excitation-current test on each phase.
- f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
- g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

G. Remove and replace units that do not pass tests or inspections and retest as specified above.

H. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 2416 - PANELBOARDS**PART 1 - GENERAL****1.1 ACTION SUBMITTALS**

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.
 - 5. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 6. Include evidence of NRTL listing for series rating of installed devices.
 - 7. Include evidence of NRTL listing for SPD as installed in panelboard.
 - 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 9. Include wiring diagrams for power, signal, and control wiring.
 - 10. Key interlock scheme drawing and sequence of operations.
 - 11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Keys: Two spares for each type of panelboard cabinet lock.
2. Circuit Breakers Including GFCI and GFEP Types: Equal to 1 percent of quantity installed for each size and type, but no fewer than two of each size and type
Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
3. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; storage in a dry space with adequate heating to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.7 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

PART 2 - PRODUCTS

2.1 PANELBOARDS GENERAL REQUIREMENTS

- A. Related Requirements
 1. 260913 "Electrical Power Monitoring And Control".
 2. 264313 "Surge Protection For Low-Voltage Electrical Power Circuits".
- B. Product selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

- F. Enclosures: Surface-mounted, as indicated, dead-front cabinets.
1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Kitchen and Wash-Down Areas: NEMA 250, Type 4X, stainless steel
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4X.
 - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.
 2. Height: 84 inches (2.13 m) maximum.
 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 4. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 5. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
- G. Phase, Neutral, and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Bus shall be fully rated the entire length.
 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- H. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Same as buses.
 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
- I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
1. Panelboards and overcurrent protective devices rated 240 V or less shall have minimum short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical where supplied from transformers rated less than 75kVA and not less than 22,000 A rms symmetrical where supplied from transformers rated 112.5kVA or greater. Short-Circuit current rating shall be greater than the maximum available fault current as determined in the power system study specified in Section 26 0573 "Power System Studies".
 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have minimum short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical. Short-Circuit current rating shall be greater than the maximum available fault current as determined in the power system study specified in Section 26 0573 "Power System Studies".

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD. Provide Type 1 for service entrance equipment; Type 2 for other panelboards as indicated or specified..

2.3 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. SIEMENS Industry, Inc.; Energy Management Division.
 - 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - 1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.
- D. Mains: As indicated.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker: Bolt-on circuit breakers or Plug-in circuit breakers where individual positive-locking device requires mechanical release for removal or fused switches as indicated.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. SIEMENS Industry, Inc.; Energy Management Division.
 - 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: As indicated.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- F. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following]
1. Eaton.
 2. ABB.
 3. SIEMENS Industry, Inc.; Energy Management Division.
 4. Square D; by Schneider Electric.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 100 A and larger.
 2. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.
 - e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) For all circuit breakers with frame sizes equal to or greater than 150A or where specifically indicated on Drawings with "I" subscript on a circuit breaker:
 - a) Instantaneous trip.
 - 2) For all circuit breakers with frame sizes equal to or greater than 150A or where specifically indicated on Drawings with "L" subscript on a circuit breaker:
 - a) Long-time pickup level.
 - b) Long-time time adjustment.
 - 3) For all circuit breakers with frame sizes equal to or greater than 150A or where specifically indicated on Drawings with "S" subscript on a circuit breaker:
 - a) Short-time pickup levels.
 - b) Short-time time adjustment.
 - 4) Where indicated on Drawings with "G" subscript on a circuit breaker or where required by NEC for circuit breakers with frame sizes rated 1000A and greater on 480V and 480Y/277V circuits:
 - a) Ground-fault pickup level, time delay, and I squared T response.
 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 6. Subfeed Circuit Breakers: Vertically mounted.
 7. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.

- c. UL listed for reverse connection without restrictive line or load ratings.
- d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
- e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
- f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- g. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system specified in Section 26 0913 "Electrical Power Monitoring and Control."
- h. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- i. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
- j. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
- k. Auxiliary Contacts: One, SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
- l. Multipole units enclosed in a single housing with a single handle or factory assembled to operate as a single unit.
- m. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
- n. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position. Provide one for each branch circuit overcurrent device serving fire alarm equipment. Handle clamps installed for fire alarm overcurrent devices shall have a red finish.

2.6 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.7 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NECA 407.
- D. Equipment Mounting:
 - 1. Install power panelboards on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases in Division 3.
 - 2. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount panelboard cabinet plumb and rigid without distortion of box.
- G. Mount surface-mounted panelboards to steel slotted supports 5/8 inch (16 mm) in depth. Orient steel slotted supports vertically.
- H. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.

- I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- J. Install filler plates in unused spaces.
- K. Install handle clamps on all branch circuit overcurrent devices serving fire alarm equipment.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 26 0553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. Do not perform optional tests. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges per Coordination Study.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.2 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1 and NEMA WD 6.
- E. Devices indicated as "tamper-resistant" shall have integral shutters that operate only when both prongs of a plug are inserted in the receptacle.
- F. Devices indicated as "weather-proof" or "weather-resistant" shall have the following:
 - 1. Spring-loaded, gasketed, "weather-proof-in-use" cover.
 - 2. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.
- G. Switches indicated as Key-switch shall have factory-supplied key in lieu of switch handle.
- H. Devices indicated or specified as anti-microbial shall have contact surfaces treated with a factory-applied coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
- I. Devices indicated or specified as decorator style shall have a rectangular face opening.
- J. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- K. Device Color:

1. Wiring Devices Connected to Normal Power System: [Almond] [Black] [Brown] [Gray] [Ivory] [White] [As selected by Architect] unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Emergency Electrical System: Red.

L. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD RECEPTACLES, 125 V, 20 A

A. Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Two pole, three wire, and self-grounding.
3. Configuration: Heavy-duty, NEMA 5-20R
4. Standards: Comply with UL 498 and FS W-C-596.

2.3 USB RECEPTACLES

A. USB Charging Receptacles:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description:
 - a. Receptacle: Duplex 20A, 125V receptacle, configuration 5-20R, with tamper-resistant shutters.
 - b. USB Ports: One USB Type A and one USB Type C port with total available charging current of 3.1A or greater at 5 VDC.
3. Standards: Comply with UL 498, UL 1310 and USB 3.0 devices.

2.4 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Non-feed through.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.5 CONTROLLED RECEPTACLES, 125 V, 20 A

- A. Duplex Controlled Receptacle, 125 V, 20 A:
 - 1. Description: Receptacle marked with the controlled receptacle symbol as required by NFPA 70 article 406.
 - 2. Configuration: Heavy-duty, NEMA WD 6, Configuration 5-20R.
 - 3. Receptacle Type: Standard, USB, GFCI, tamper-resistant, hospital-grade, or any combination thereof as required to meet the requirements of this Section pertaining to where specific receptacle types are required, or as specifically indicated on Drawings.
 - 4. Switching Configuration: Half-controlled or full controlled as indicated on Drawings.

2.6 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, amperage, voltage, and NEMA configuration as indicated on the Drawings: Comply with NEMA WD 1 and UL 498.
 - 1. Products: Subject to compliance with the requirements, provide products by one of the following manufacturers:
 - a. Cooper
 - b. Hubbell
 - c. Leviton
 - d. Pass & Seymour

2.7 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector, heavy-duty grade.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton (Arrow Hart).
 - 2. Hubbell Premise Wiring.
 - 3. Leviton Manufacturing Co., Inc.
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- C. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R.
- D. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- E. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
- F. Standards: Comply with FS W-C-596.

2.8 TOGGLE SWITCHES, 120/277 V, 20 A

- A. Snap Switches, 120/277 V, 20 A :
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).

- b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Standards: Comply with UL 20 and FS W-S-896.
- B. Pilot-Light, Snap Switches: 120/277 V, 20 A:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Description: Illuminated when switch is **[on]** **[off]**.
 - 3. Standards: Comply with UL 20 and FS W-S-896.

2.9 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices.
- B. Single and combination types shall match corresponding wiring devices.
- 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting Smooth, high-impact thermoplastic, color as selected by Architect 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel 0.04-inch- (1-mm-) thick, brushed brass with factory polymer finish 0.05-inch- (1.2-mm-) thick, anodized aluminum 0.04-inch- (1-mm-) thick steel with chrome-plated finish.
 - 3. Material for Unfinished Spaces: Galvanized steel Smooth, high-impact thermoplastic.
 - 4. Material for Damp Locations: Thermoplastic Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum thermoplastic with lockable cover.

2.10 SURFACE RACEWAYS

- A. Description: Two-piece, aluminum construction multioutlet assembly with brushed natural or satin anodized natural finish with devices, junction fittings, and other matching accessories as required for a complete system and per UL 5.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Wiremold / Legrand.
 - 3. MonoSystems, Inc.
- C. General:
- 1. Components shall be products from single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
 - 2. Provide continuous one-piece cover plates, minimum four feet long.
 - 3. Provide GFCI receptacles for sections of multioutlet assemblies that are indicated within 6'-0" of the edge of a sink.

4. Wiring: Minimum no. 12 AWG solid, Type THHN copper. Provide larger conductor sizes where receptacles with ampacities greater than 20-amperes are indicated.
- D. Surface Raceway Type SR-1
1. Multioutlet assembly with prewired, 20-ampere, 125-volt, 2-pole, 3-wire duplex receptacles on [9] [12] [18]-inch centers, alternately connected to [one] [two] [three] 20-ampere circuits, 120-volt circuits with ground.
 2. Receptacle Finish: Grey
- E. Surface Raceway Type SR-2
1. Two-compartment multioutlet assembly with full length divider.
 - a. Section 1: Prewired, 20-ampere, 125-volt, 2-pole, 3-wire duplex receptacles on [9] [12] [18]-inch centers, alternately connected to [one] [two] [three] 20-ampere circuits, 120-volt circuits with ground.
 - b. Section 2: Rectangular single gang openings on [9] [12] [18] [24]-inch centers for use by communications cabling contractor to install the facility standard data faceplate in the surface raceway.
 2. Receptacle Finish: Grey
- F. Surface Raceway Type SR-3
1. Three-compartment multioutlet assembly with full length dividers.
 - a. Section 1: Prewired, 20-ampere, 125-volt, 2-pole, 3-wire duplex receptacles on [9] [12] [18]-inch centers, alternately connected to [one] [two] [three] 20-ampere circuits, 120-volt circuits with ground.
 - b. Section 2: Same as section 1, except emergency power receptacles.
 - c. Section 3: Rectangular single gang openings on [9] [12] [18] [24]-inch centers for use by communications cabling contractor to install the facility standard data faceplate in the surface raceway.
 2. Receptacle Finish:
 - a. Normal Power: Grey
 - b. Emergency Power: Red

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.

- C. Conductors:
1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted, provided the outlet box is large enough.
- D. Device Installation:
1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Type:
1. Install GFCI receptacles for all receptacles supplied by single-phase branch circuits rated 150V or less to ground in the following spaces/locations:
 - a. Bathrooms.
 - b. Kitchens or similar areas with a sink and permanent provisions for either food preparation or cooking.
 - c. Buffet serving areas with permanent provisions for food serving, beverage serving, or cooking.
 - d. Where the receptacle is installed within 6 feet of the edge of a sink.
 - e. Outdoors.
 - f. Indoor damp and wet locations.
 - g. Locker rooms with associated showering facilities.
 - h. Garages, accessory buildings, service bays, and similar areas.
 - i. Laundry areas.
 2. Install GFCI receptacles at the following equipment supplied by single-phase branch circuits rated 150V or less to ground and 60 amperes:
 - a. Automotive vacuum machines
 - b. Drinking water coolers and bottle fill stations
 - c. High-pressure spray washing machines

- d. Tire inflation machines
 - e. Vending machines
 - f. Sump pumps
 - g. Dishwashers
 - h. Electric Ranges
 - i. Wall-mounted ovens
 - j. Counter-mounted cooking units
 - k. Clothes dryers
 - l. Microwave ovens
3. Where GFCI receptacles cannot be installed in a readily accessible location or are not available in the receptacle configuration required to serve a specific load, provide equivalent ground fault circuit interrupter protection by installing a GFCI type circuit breaker as the branch circuit overcurrent protective device for the load.
4. Install tamper-resistant versions of the specified receptacles for all 20A, 125V and 250V nonlocking-type receptacles in the following areas:
- a. All spaces in educational facilities.
 - b. Business offices, corridors, waiting rooms, and similar spaces in clinics, medical and dental offices, and outpatient healthcare facilities.
 - c. Dormitory units.
 - d. Gymnasiums.
 - e. Auditoriums.
 - f. All spaces in assisted living facilities.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- 3.2 IDENTIFICATION
- A. Comply with Section 26 0553 "Identification for Electrical Systems."
- B. Identify each wiring device with panelboard identification and circuit number. In spaces where low voltage lighting control wall stations are utilized, identify panelboard and circuit number of the lights controlled by the low voltage device. In spaces with multiple lighting circuits, provide multiple labels to indicate each lighting branch circuit serving the space. Use hot, stamped, or engraved machine printing with black-filled lettering on front face of plate, and durable wire markers or tags inside outlet boxes.
- 3.3 FIELD QUALITY CONTROL
- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.

- C. Perform the following tests and inspections:
 - 1. In healthcare facilities, prepare reports that comply with NFPA 99.
 - 2. Test Instruments: Use instruments that comply with UL 1436.
 - 3. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Wiring device will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 26 2813 - FUSES**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section Includes:
 - 1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Panelboards.
 - c. Enclosed controllers.
 - d. Enclosed switches.
 - 2. Spare-fuse cabinets.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 - 3. Current-limitation curves for fuses with current-limiting characteristics.
 - 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse. Submit in electronic format suitable for use in coordination software and in PDF format.
 - 5. Coordination charts and tables and related data.
 - 6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7700 "Closeout Procedures," or Section 01 7823 "Operation and Maintenance Data," include the following:
 - 1. Ambient temperature adjustment information.
 - 2. Current-limitation curves for fuses with current-limiting characteristics.
 - 3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
 - 4. Coordination charts and tables and related data.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.5 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Bussmann, an Eaton business.
 2. Edison; a brand of Bussmann by Eaton.
 3. Littelfuse, Inc.
 4. Mersen USA.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 1. Type RK-1: 250 and 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 2. Type RK-5: 250 and -V, zero- to 600-A rating, 200 kAIC, time delay.
 3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting .
 4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, fast acting .
 5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 2. Finish: Gray, baked enamel.
 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.

4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 1. Provide fuses from the same manufacturer to insure retention of selective protective device coordination.
 2. Fuses rated 600 amperes and less: UL Class RK1 unless otherwise indicated or specified, current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms.
 - a. Provide UL Class RK5 fuses current-limiting, time-delay, per UL 198E, with an interrupting rating of 100,000 amperes rms, as follows:
 - 1) Motor starters size 3 and smaller.
 - 2) Panelboard main fuses where the amperage ratio between the main fuse to the largest feeder fuse is at least 2:1.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Architect.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.
- B. Shop Drawings: For enclosed switches and circuit breakers.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Include wiring diagrams for power, signal, and control wiring.

1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.2 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. ABB.
 - 3. Siemens Industry, Inc.
 - 4. Square D; by Schneider Electric.
- B. Type HD, Heavy Duty:
 - 1. Single throw.
 - 2. Three pole, unless otherwise indicated.
 - 3. 240 or 600-V ac.
 - 4. Ampacity as indicated or scheduled.
 - 5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified or indicated fuses.
 - 6. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Early Break Auxiliary Contacts: 1 set of normally open contacts that has an early break feature which breaks the contacts prior to the disconnect switch being fully placed in the OFF position.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Arc-Energy Reduction Relay: For switches rated 1200A, provide internally mounted device compliant with NFPA 70 article 240.67 requirements, with external display containing pushbutton and visual indicator for maintenance mode.
 - 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 6. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1); [gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R, 12); [a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel); copper-free cast aluminum alloy (NEMA 250 Types 7, 9).
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.

- D. Operating Mechanism: The circuit-breaker operating handle shall be [directly operable through the front cover of the enclosure (NEMA 250 Type 1); directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R); externally operable with the operating mechanism being an integral part of the cover (NEMA 250 Types 7, 9). The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Kitchen and Wash-Down Areas: NEMA 250, Type 4X , stainless steel .
 - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4 .
 - 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.2 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NFPA 70 and NECA 1.
- F. Where motor disconnect switches are installed downstream of a variable frequency drive (VFD), provide 2#12 AWG conductors from the disconnect switch to the VFD. Terminate wiring in disconnect switch at early break auxiliary contacts and coordinate programming and terminating of conductors at VFD with VFD installer.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
 - h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
 - i. Verify correct phase barrier installation.
 - j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
 - 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.

- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
 - d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
 - 1. Test procedures used.
 - 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
 - 3. List deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

SECTION 26 2913.03 - MANUAL AND MAGNETIC MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes low voltage manual and magnetic motor controllers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each type of magnetic controller.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Indicate dimensions, weights, required clearances, and location and size of each field connection.
 - 3. Wire Termination Diagrams and Schedules: Include diagrams for signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Include features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- C. Product Schedule: List the following for each enclosed controller:
 - 1. Each installed magnetic controller type.
 - 2. NRTL listing.
 - 3. Factory-installed accessories.
 - 4. Nameplate legends.
 - 5. SCCR of integrated unit.
 - 6. For each combination magnetic controller include features, characteristics, ratings, and factory setting of the SCPD and OCPD.
 - a. Listing document proving Type 2 coordination.
 - 7. For each series-rated combination state the listed integrated short-circuit current (withstand) rating of SCPD and OCPDs by an NRTL acceptable to authorities having jurisdiction.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For magnetic controllers to include in operation and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:

- a. Routine maintenance requirements for magnetic controllers and installed components.
- b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
- c. Manufacturer's written instructions for setting field-adjustable overload relays.
- d. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Indicating Lights: Two of each type and color installed.
 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least [50 W] <insert number>per controller.

1.8 FIELD CONDITIONS

- A. Ambient Environment Ratings: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than 23 deg F (minus 5 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m) for electromagnetic and manual devices.
 3. The effect of solar radiation is not significant.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. UL Compliance: Fabricate and label magnetic motor controllers to comply with UL 508 and UL 60947-4-1.
- C. NEMA Compliance: Fabricate motor controllers to comply with ICS 2.

2.2 MANUAL MOTOR CONTROLLERS

- A. Motor-Starting Switches (MSS): "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton.
 - b. General Electric Company.
 - c. Rockwell Automation, Inc.
 - d. Siemens Industry, Inc.
 - e. Square D; by Schneider Electric.
 - 2. Standard: Comply with NEMA ICS 2, general purpose, Class A.
 - 3. Configuration: Nonreversing.
 - 4. Surface mounting.
 - 5. Red pilot light.

2.3 COMBINATION FULL-VOLTAGE MAGNETIC MOTOR CONTROLLER

- A. Description: Factory-assembled, combination full-voltage magnetic motor controller consisting of the controller described in this article, indicated disconnecting means, SCPD and OCPD, in a single enclosure.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. General Electric Company.
 - 3. Siemens Industry, Inc.
 - 4. Square D; by Schneider Electric.
- C. Standard: Comply with NEMA ICS 2, general purpose, Class A.
- D. Configuration: Nonreversing.
- E. Contactor Coils: Pressure-encapsulated type with coil transient suppressors when indicated.
 - 1. Operating Voltage: Manufacturer's standard, unless indicated.
- F. Control Power:

1. For on-board control power, obtain from line circuit or from integral CPT. The CPT shall have capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. Spare CPT Capacity as Indicated on Drawings: 50 VA.
 - G. Overload Relays:
 1. Thermal Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 20 tripping characteristic.
 - c. Heaters in each phase shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
 - H. Fusible Disconnecting Means:
 1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate indicated fuses.
 2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - I. Nonfusible Disconnecting Means:
 1. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 2.4 ENCLOSURES
- A. Comply with NEMA 250, type designations as indicated on Drawings, complying with environmental conditions at installed location.
 - B. The construction of the enclosures shall comply with NEMA ICS 6.
 - C. Controllers in hazardous (classified) locations shall comply with UL 1203.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and space conditions for compliance with requirements for motor controllers, their relationship with the motors, and other conditions affecting performance of the Work.

3.2 INSTALLATION

- A. Provide combination magnetic motor controllers where indicated on Drawings and for all three-phase motor/pump loads which are not indicated to have another method of control such as a VFD, ECM controller, or a packaged controller.
- B. Mount motor controllers within sight of the motor they control. Where motor controllers are mounted remotely from the motor such that the motor cannot be seen and/or is greater than 50' away, provide an additional local disconnecting means at the motor.
- C. Comply with NECA 1.

- D. Wall-Mounted Controllers: Install magnetic controllers on walls with tops at uniform height indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 0529 "Hangers and Supports for Electrical Systems" unless otherwise indicated.
- E. Comply with requirements for seismic control devices specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."
- F. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- G. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- H. Setting of Overload Relays: Select and set overloads on the basis of full-load current rating as shown on motor nameplate. Adjust setting value for special motors as required by NFPA 70 for motors that are high-torque, high-efficiency, and so on.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Tests and Inspections:
 - 1. Comply with the provisions of NFPA 70B, "Testing and Test Methods" Chapter.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with drawings and specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, and grounding.
 - d. Verify the unit is clean.
 - e. Inspect contactors:
 - 1) Verify mechanical operation.
 - 2) Verify contact gap, wipe, alignment, and pressure are according to manufacturer's published data.
 - f. Motor-Running Protection:
 - 1) Verify overload element rating is correct for its application.
 - 2) If motor-running protection is provided by fuses, verify correct fuse rating.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter. Compare bolted connection resistance values with values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.

- 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- h. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
3. Electrical Tests:
 - a. For the contactor and circuit breaker, perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Insulation-resistance values shall be according to manufacturer's published data or NETA ATS Table 100.1. In the absence of manufacturer's published data, use Table 100.5. Values of insulation resistance less than those of this table or manufacturer's recommendations shall be investigated and corrected.
 - b. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
 - c. Test motor protection devices according to manufacturer's published data.
 - d. Test circuit breakers as follows:
 - 1) Operate the circuit breaker to ensure smooth operation.
 - 2) For adjustable circuit breakers, adjust protective device settings according to the coordination study. Comply with coordination study recommendations.
 - e. Perform operational tests by initiating control devices.
4. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove all necessary covers prior to the inspection.
 - a. Comply with the recommendations of NFPA 70B, "Testing and Test Methods" Chapter, "Infrared Inspection" Article.
 - b. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of each motor controller.
 - c. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each motor controller 11 months after date of Substantial Completion.
 - d. Report of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used, and lists the following results:
 - 1) Description of equipment to be tested.
 - 2) Discrepancies.
 - 3) Temperature difference between the area of concern and the reference area.
 - 4) Probable cause of temperature difference.
 - 5) Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - 6) Load conditions at time of inspection.
 - 7) Photographs and thermograms of the deficient area.
 - 8) Recommended action.
 - e. Equipment: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 degree C at 30 degrees C. The equipment shall detect emitted radiation and convert detected radiation to a visual signal.
 - f. Act on inspection results and recommended action, and considering the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

- E. Motor controller will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.4 SYSTEM FUNCTION TESTS

- A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.
 - 1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
 - 2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
 - 3. Verify the correct operation of sensing devices, alarms, and indicating devices.
- B. Motor controller will be considered defective if it does not pass the system function tests and inspections.
- C. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

END OF SECTION

SECTION 26 2923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.2 DEFINITIONS

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformer.
- C. DDC: Direct digital control.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each VFC indicated.
 - 1. Include mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Required working clearances and required area above and around VFCs.
 - 2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
 - 3. Show support locations, type of support, and weight on each support.
 - 4. Indicate field measurements.
- B. Qualification Data: For testing agency.
- C. Product Certificates: For each VFC from manufacturer.
- D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
 - f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB Low Voltage HVAC Drives. (Basis-of-Design)
 2. Cerus Industrial, Inc.
 3. Danfoss Inc.
 4. Eaton.
 5. Emerson Industrial Automation.
 6. General Electric Company.
 7. Rockwell Automation, Inc.
 8. Schneider Electric USA, Inc.
 9. SIEMENS Industry, Inc.; Energy Management Division.
 10. Yaskawa Electric America, Inc.

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:
 1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 61800-5-1.
- B. Application: variable torque .
- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 1. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 2. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
 1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.
 2. Input AC Voltage Unbalance: Not exceeding 3 5 percent.
 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 4. Minimum Efficiency: 96 97 Insert number percent at 60 Hz, full load.
 5. Minimum Displacement Primary-Side Power Factor: 96 98 Insert number percent under any load or speed condition.
 6. Minimum Short-Circuit Current (Withstand) Rating: 65 Insert value kA.
 7. Ambient Temperature Rating: Not less than 32 deg F (0 deg C) and not exceeding 104 deg F (40 deg C).
 8. Humidity Rating: Less than 95 percent (noncondensing).
 9. Altitude Rating: Not exceeding 3300 feet (1000 m).
 10. Vibration Withstand: Comply with NEMA ICS 61800-2.
 11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus 5 percent.
 14. Output Carrier Frequency: Selectable; 0.5 to insert number kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
 1. Signal: Electrical.
- I. Internal Adjustability Capabilities:
 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 999.9 seconds.
 4. Deceleration: 0.1 to 999.9 seconds.

5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:
 1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under- and overvoltage trips.
 4. Inverter overcurrent trips.
 5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 6. Critical frequency rejection, with three selectable, adjustable deadbands.
 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor-overtemperature fault.
- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- M. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- N. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- O. Integral Input Disconnecting Means and OCPD: UL 489, thermal-magnetic circuit breaker with pad-lockable, door-mounted handle mechanism.
 1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
 2. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.
 3. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
 4. NO alarm contact that operates only when circuit breaker has tripped.

2.3 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
 1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.

- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
1. Electric Input Signal Interface:
 - a. A minimum of two Insert number programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 3. Output Signal Interface: A minimum of one two programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).

4. Remote Indication Interface: A minimum of two Insert number programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- F. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
 1. Hardwired Points:
 - a. Monitoring: On-off status, Insert monitoring point.
 - b. Control: On-off operation, Insert control point.
 2. Communication Interface: Comply with ASHRAE 135 Insert type of interface. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

2.4 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.
- B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for .

2.5 OPTIONAL FEATURES

- A. Damper control circuit with end-of-travel feedback capability.
- B. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
- C. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
- D. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station smoke-control fan controller Insert location, this password-protected input:
 1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
 2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
 3. Causes display of override mode on the VFC display.
 4. Reset VFC to normal operation on removal of override signal manually.
- E. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- F. Remote digital operator kit.

- G. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.6 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: Type 1.
 - 2. Kitchen Wash-Down Areas: Type 4X, stainless steel Insert material.
 - 3. Other Wet or Damp Indoor Locations: Type 4.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.7 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
 - 1. Push Buttons: Covered Lockable Shielded Unguarded.
 - 2. Pilot Lights: Push to test.
 - 3. Selector Switches: Rotary Insert description type.
 - 4. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- B. [NC] [NO] [Reversible NC/NO] bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable pneumatic solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 - 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- E. Supplemental Digital Meters:
 - 1. Elapsed-time meter.
 - 2. Kilowatt meter.
 - 3. Kilowatt-hour meter.
- F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 12 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

- H. Cooling Fan and Exhaust System: For NEMA 250, Type 1 Type 12 Insert enclosure type; UL 508 component recognized: Supply fan, with composite stainless-steel Insert material intake and exhaust grills and filters; 120 Insert number-V ac; obtained from integral CPT Insert source of control power.
- I. Spare control-wiring terminal blocks; unwired.

2.8 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2 Insert standard.
 - 1. Test each VFC while connected to its specified motor.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 26 0529 "Hangers and Supports for Electrical Systems."
- B. Floor-Mounting Controllers: Install VFCs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete." or Section 03 3053 "Miscellaneous Cast-in-Place Concrete."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
1. Curbs and roof penetrations are specified in Section 07 7200 "Roof Accessories."
 2. Structural-steel channels are specified in Section 26 0529 "Hangers and Supports for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in each fusible-switch VFC.
- F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 2813 "Fuses."
- G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Comply with NECA 1.
- 3.3 CONTROL WIRING INSTALLATION
- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 26 0523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.
- 3.4 IDENTIFICATION
- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each VFC with engraved nameplate.
 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Acceptance Testing Preparation:
1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- E. Tests and Inspections:
1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
 3. Test continuity of each circuit.
 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Construction Manager before starting the motor(s).
 5. Test each motor for proper phase rotation.
 6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- F. VFCs will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect and Construction Manager before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers.
- E. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 0573 "Coordination Studies."
- F. Set field-adjustable pressure switches.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION

SECTION 26 3213 - ENGINE GENERATORS**PART 1 - GENERAL****1.1 SUMMARY**

- A. This Section includes packaged engine-generator sets for [**emergency**] [**and**] [**standby**] power supply with the features as specified and indicated.
- B. Related Sections include the following:
 - 1. Division 26 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.2 DEFINITIONS

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.3 SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:
 - 1. Thermal damage curve for generator.
 - 2. Time-current characteristic curves for generator protective device.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Dimensioned outline plan and elevation drawings of engine-generator set and other components specified.
 - 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 - 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Compliance Statement
 - 1. Submit a document which states whether the proposed product(s) either comply or deviate from the Specification requirements. This includes all Part 1, Part 2, and Part 3 specification items. Specification requirements not noted as deviations will be assumed as complying.
 - 2. Provide the statement in an itemized, columnar format as follows:
 - a. Column 1 - Reference to the specification item, organized in the same sequential order as in the Specification.
 - b. Column 2 - Explanation for noted deviations.
- D. Qualification Data: For .

- E. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than [**200 miles (321 km)**] <Insert number of miles (km)> from Installer's place of business to Project site.
 - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 37.
- G. Comply with NFPA 70.
- H. Comply with NFPA 99.
- I. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- J. Comply with UL 2200.
- K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.5 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.
- B. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: 5 to 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet (300 m).

1.6 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: < **Insert number** > years from date of Substantial Completion.

1.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Date of Acceptance, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 - 2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
 - 3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Caterpillar; Engine Div.
 2. Generac Power Systems, Inc.
 3. Onan/Cummins Power Generation; Industrial Business Group.
 4. MTU Onsite Energy Corporation.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
1. Power Output Ratings: Continuous electrical output power rating for standby operation of not less than 200 kW, at 80 percent lagging power factor, 480/277 -volt, three phase, 4-wire, 60 hertz. In addition, provide power required for generator accessories including battery charger and radiator.
 2. Provide generator with a minimum motor starting capability of 1250 SkVA and capable of sustaining a minimum of 90 percent of rated no-load voltage with the specified kVA load at near zero power factor applied to the generator.
 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance:
1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
 2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
 3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
 4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
 6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Natural gas with automatic LP-gas standby Natural gas.
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm .
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 1. Dual Natural Gas :
 - a. Carburetor.
 - b. Secondary Gas Regulators: One for each fuel type.
 - c. Fuel-Shutoff Solenoid Valves: One for each fuel source.
 - d. Flexible Fuel Connectors: One for each fuel source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

Generator Size	Heater Voltage
0-400 kW	120 or 208 single phase
400-800 kW	208 or 480 single phase
Above 800 kW	480 single phase

 1. Suitable for operation on 208 -volt, single phase, 60 hertz power.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

4. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

- I. Cooling System: Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
 1. Configuration: [**Vertical**] [**Horizontal**] air discharge.
 2. Radiator Core Tubes: [**Aluminum**] [**Nonferrous-metal construction other than aluminum**].
 3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
 4. Fan: Driven by [**multiple belts from engine shaft**] [**totally enclosed electric motor with sealed bearings**].
 5. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 6. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

- J. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 1. Minimum sound attenuation of 25 dB at 500 Hz.
 2. Sound level measured at a distance of 10 feet from exhaust discharge after installation is complete shall be 85 dBA or less.

- K. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

- L. Starting System: 24-V electric, with negative ground.
 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 4. Battery: Lead-acid adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least [**twice**] [**three times**] without recharging.
 5. Battery Cable: Size as recommended by engine manufacturer for cable length as required. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
 - e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
 1. Engine start circuits from emergency and fire pump transfer switches shall be monitored for broken, shorted, or disconnected wires as required by NFPA 70 articles 695 and 700. Loss of start circuit wiring shall start the generator. Provide all control wiring and hardware required to provide engine start circuit integrity monitoring as required by the referenced code articles.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
- D. Configuration: Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
 1. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.

2. Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards."
 3. Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-Voltage Switchgear."
 4. Current and Potential Transformers: Instrument accuracy class.
- E. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
- F. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- G. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring and Control."
- H. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
1. Overcrank shutdown.
 2. Coolant low-temperature alarm.
 3. Control switch not in auto position.
 4. Battery-charger malfunction alarm.
 5. Battery low-voltage alarm.
- I. Common Remote Audible Alarm: Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
- J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

2.5 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, true RMS sensing electronic-trip type; 100 percent rated; complying with UL 489.
1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 2. Trip Settings: Selected to coordinate with generator thermal damage curve.
 3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.

5. Main circuit breaker UL-listed as service-entrance equipment.
 - B. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
 1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
 2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
 3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
 4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
 - C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.
- 2.6 GENERATOR, EXCITER, AND VOLTAGE REGULATOR
- A. Comply with NEMA MG 1.
 - B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
 - C. Electrical Insulation: Class H or Class F.
 - D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
 - E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
 - F. Enclosure: Dripproof.
 - G. Instrument Transformers: Mounted within generator enclosure.
 - H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
 - I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

2.7 LOAD BANK

- A. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive unit capable of providing a balanced 3-phase, delta-connected load to generator set at 100 percent rated-system capacity, at 80 percent power factor, lagging. Unit may be composed of separate resistive and reactive load banks controlled by a common control panel. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
1. Unit shall be mounted on top of generator outdoor weather enclosure.
- B. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases.
- C. Reactive Load Elements: Epoxy-encapsulated reactor coils.
- D. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
- E. Load Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
- F. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
- G. Load-Bank Enclosures: NEMA 250, Type 3R, complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with 1/2-inch-square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge.
- H. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
- I. Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
- J. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Prefabricated or preengineered walk-in enclosure with the following features:
1. Provide enclosure which maintains a minimum interior ambient temperature of 40 degrees F per NFPA 110.
 2. Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
 3. Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
 4. Space Heater: Thermostatically controlled and sized to prevent condensation.
 5. Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
 6. Hinged Doors: With padlocking provisions.
 7. Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
 8. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components and NFPA 110.
 9. Muffler Location: [Within] [External to] enclosure.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
- C. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
1. AC lighting system and connection point for operation when remote source is available.
 2. DC lighting system for operation when remote source and generator are both unavailable.
- D. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.
- E. Load Center: Provide a 208Y/120V, 3 Phase, 4 Wire, 100A MCB (main circuit breaker) type panelboard within the enclosure for power service to generator accessories including but not limited to: battery charger, jacket water heaters, lights, receptacles, enclosure heater, and motorized dampers. Generator accessories shall be factory wired to the panelboard. All internal wiring shall be type THHN/THWN-2 in EMT in accordance with all governing codes. If load center is located near the air intake louver and will be subject to moisture from rain or snow, provide a NEMA 3R enclosure.

2.9 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
1. Material: [**Standard neoprene**] [**Natural rubber**] [**Bridge-bearing neoprene**, complying with AASHTO M 251].

2. Durometer Rating: [30] [40] [45] [50] [60] [65] [70] <Insert number>.
3. Number of Layers: [One] [Two] [Three] [Four] <Insert number>.

- B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
 3. Minimum Additional Travel: 50 percent of required deflection at rated load.
 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.10 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer. Outdoor enclosure finish color shall be selected by Architect.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator set and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. Full load run.
 3. Maximum power.
 4. Voltage regulation.
 5. Transient and steady-state governing.
 6. Single-step load pickup.
 7. Safety shutdown.
 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 9. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with vibration isolation devices as specified having a minimum deflection of 1 inch. Insert static deflection on 4-inch- high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- D. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and . Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- E. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
 - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 1. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-Gas Piping."

2. LP-gas piping, valves, and specialties for gas piping are specified in Division 23 Section "Facility Liquefied-Petroleum Gas Piping."
- F. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- G. Connect power wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- H. Provide engine start wiring from generator controller to transfer switches. Engine start wiring shall be type and size as recommended by manufacturer. Where manufacturer does not have a specific recommendation, provide #12 AWG THHN/THWN-2 conductors.
 1. Route engine start wiring in separate raceways and entirely independent from all wiring
 2. Coordinate engine start signal wiring installation with transfer switch manufacturer and installer. For emergency and fire pump transfer switches, ensure proper connection and operation of the engine start circuit integrity monitoring required by NFPA 70 articles 695 and 700.
- I. Provide power and communications wiring for remote generator annunciator (derangement) panel. Provide wiring type and size as recommended by manufacturer.
 1. Where generator annunciator panel location is not specifically indicated on Drawings, coordinate exact location with Owner prior to installation.
 - 2.
 - 3.

3.4 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection[**(except those indicated to be optional)**] for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at **[four]** **<Insert number> locations [on the property line] <Insert location for measurement>**, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- H. Remove and replace malfunctioning units and retest and reinspect as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- 3.6 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Division 01 Section "Demonstration and Training."

June 15, 2026

Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 3600 - TRANSFER SWITCHES**PART 1 - GENERAL****1.1 ACTION SUBMITTALS**

- A. Coordination of Submittals: Include preliminary power system studies with submittal or submit to Architect prior to submittal. Refer to Section 26 0573 "Power System Studies" for additional requirements. Transfer switches submitted prior to preliminary power system studies will be returned without review.
- B. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
 - 2. Include material lists for each switch specified.
 - 3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
 - 4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.

1.2 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer-authorized service representative.
- B. Field quality-control reports.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Features and operating sequences, both automatic and manual.
 - b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications:
 - 1. Member company of NETA.
 - a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 99.
- D. Comply with NFPA 110.
- E. Comply with UL 1008 unless requirements of these Specifications are stricter.
- F. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- G. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Short-time withstand capability for 3 cycles.
- H. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- I. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- J. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- L. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.

- M. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 26 0553 "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - 4. Accessible via front access.
- N. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Caterpillar, Inc.; Electric Power Division.
 - 2. Cummins Power Generation.
 - 3. Eaton.
 - 4. ASCO Power Technologies.
 - 5. Generac Power Systems, Inc.
 - 6. Russelectric, Inc.
 - 7. ABB.
- B. Comply with Level 1 equipment according to NFPA 110.
- C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
 - 4. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 5. Material: Hard-drawn copper, 98 percent conductivity.
 - 6. Main and Neutral Lugs: Mechanical type.
 - 7. Ground Lugs and Bus-Configured Terminators: Compression Mechanical type.
 - 8. Connectors shall be marked for conductor size and type according to UL 1008.
- D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
 - 1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
- E. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

- F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.
- G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- H. Automatic Transfer-Switch Controller Features:
 - 1. Controller operates through a period of loss of control power.
 - 2. Undervoltage Sensing for Each Phase of Normal [**and Alternate**] Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - 5. Test Switch: Simulate normal-source failure.
 - 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 - 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
 - 8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
 - 9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
 - 10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open, rated 10 A at 32-V dc minimum.
 - 11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
 - 12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is unavailable.
- I. Large-Motor-Load Power Transfer:

1. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 TRANSFER SWITCH ACCESSORIES

A. Bypass/Isolation Switches:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Comply with requirements for Level 1 equipment according to NFPA 110.
3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
 - b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
 - c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
 - d. Transition: Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.
 - e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer switch contacts when they are carrying rated load.
 - g. Manual Control: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less. Operating handles shall be externally operated.
 - h. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - i. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

B. Remote Annunciator and Control System:

1. Source Limitations: Same manufacturer as transfer switch in which installed.
2. Include the following functions for indicated transfer switches:
 - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Indication of switch position.
 - c. Indication of switch in test mode.
 - d. Indication of failure of digital communication link.
 - e. Key-switch or user-code access to control functions of panel.

- f. Control of switch-test initiation.
 - g. Control of switch operation in either direction.
 - h. Control of time-delay bypass for transfer to normal source.
 - 3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
 - 4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - a. Controls and indicating lights grouped together for each transfer switch.
 - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
 - c. Digital Communication Capability: Matched to that of transfer switches supervised.
 - d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.
- C. Digital Power Meter
- 1. Mounting: Flush in front door of transfer switch
 - 2. Display: Digital LCD
 - 3. Metered Parameters:
 - a. LL/LN Voltage
 - b. A,B,C, N Currents
 - c. Power (kW, kVA, kVAR)
 - d. Power Factor
 - e. Frequency
 - f. kW Demand
 - g. Accumulated Energy (kWh, kVAh, kVARh)
 - h. Total Harmonic Distortion (THD)
 - i. Min/max historical values
 - 4. Accuracy:
 - a. Current, Voltage, Power, Frequency: 1.0%
 - b. Energy, Power Factor, Demand: 1.0%
 - 5. Displaying of each of the metered quantities shall be accomplished through the use of menu scroll buttons.
 - 6. Reset of stored historical values and accumulated values shall be performed through the local access display. All reset functions shall have a means for protection against unauthorized/accidental changes.
 - 7. Provide current transformers as required to provide specified metering functions and accuracy.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.
- B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency and legally required systems. Include results of test for the following conditions:
 - a. Overvoltage.
 - b. Undervoltage.
 - c. Loss of supply voltage.
 - d. Reduction of supply voltage.
 - e. Alternative supply voltage or frequency is at minimum acceptable values.
 - f. Temperature rise.
 - g. Dielectric voltage-withstand; before and after short-circuit test.
 - h. Overload.
 - i. Contact opening.
 - j. Endurance.
 - k. Short circuit.
 - l. Short-time current capability.
 - m. Receptacle withstand capability.
 - n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
 3. Provide workspace and clearances required by NFPA 70.
- B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.
- C. Identify components according to Section 26 0553 "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
 - 1.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, motor controls, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.
 1. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

- D. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect twisted pair cable according to Section 26 0513 "Low-Voltage Electrical Power Conductors and Cables."
- G. Connect twisted pair cable according to manufacturer's installation instructions.
- H. Route and brace conductors according to manufacturer's written instructions and Section 26 0529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.
- I. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing equipment, test for compliance with requirements according to NETA ATS.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify that the unit is clean.
 - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - f. Verify that manual transfer warnings are attached and visible.
 - g. Verify tightness of all control connections.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
 - i. Perform manual transfer operation.
 - j. Verify positive mechanical interlocking between normal and alternate sources.
 - k. Perform visual and mechanical inspection of surge arresters.
 - l. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.

- 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
 - a. Perform insulation-resistance tests on all control wiring with respect to ground.
 - b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
 - c. Verify settings and operation of control devices.
 - d. Calibrate and set all relays and timers.
 - e. Verify phase rotation, phasing, and synchronized operation.
 - f. Perform automatic transfer tests.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay on transfer.
 - 4) Alternative source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer on normal power restoration.
 - 8) Engine cool-down and shutdown feature.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for one pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.

- D. Coordinate tests with tests of generator and run them concurrently.
- E. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- F. Transfer switches will be considered defective if they do not pass tests and inspections.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
- B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.
- C. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 26 3650 - GENERATOR DOCKING STATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes generator docking stations (also referred to as quick-connect panels) rated 600V and less.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
 - 2. Include material lists for each switch specified.
 - 3. Single-Line Diagram: Show connections between permanent generator, load bank, temporary generator, automatic transfer switch. Show interlocking provisions as specified.
 - 4. Riser Diagram: Show interconnection wiring between docking station, remote transfer switches, power sources, power distribution equipment, remote start contacts, remote alarm and control panels.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer-authorized service representative
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operations and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Comply with NFPA 110.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 WARRANTY

- A. The equipment installed under this contract shall be left in proper working order.
- B. New materials and equipment shall be guaranteed against defects in composition, design or workmanship. Guarantee certificates shall be furnished.

PART 2 - PRODUCTS

2.1 GENERATOR DOCKING STATION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Trystar
 - 2. Power Temp Systems
 - 3. ASCO
 - 4. Eaton
 - 5. ESL Power Systems

2.2 GENERAL REQUIREMENTS

- A. Docking station shall include 16 Series Camlok Panel Mounts for use as connection to Portable Generator and/or Temporary Load Bank as indicated on Drawings.
- B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.
- C. Enclosures:
 - 1. NEMA 3R aluminum enclosure.
 - a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or portable load bank. NEMA integrity shall be maintained with access plate open for cable entry.
 - b. Front and side through a front access panel shall be accessible for maintenance.
 - c. Top, side, and bottom through a front access panel shall be accessible for permanent cabling.
 - 2. Finishes:
 - a. Paint after fabrication. Powder coated manufacturer's standard grey.
- D. Phase, Neutral, and Ground Buses:
 - 1. Material: Tin-plated or Silver-plated Copper
 - 2. Equipment Ground Bus: bonded to box.
 - 3. Ground Bus: 50% of phase size.
 - 4. Neutral Bus: Neutral bus rated 100 percent of phase bus.

- E. Temporary generator connectors shall be Camlok style mounted on gland plate.
1. Camlok shall be color coded according to system voltage
 - a. A phase: Black (208/120V) or Brown (480/277V)
 - b. B phase: Red (208/120V) or Orange (480/277V)
 - c. C phase: Blue (208/120V) or Yellow (480/277V)
 - d. N Neutral: White
 - e. G Ground: Green
- F. Temporary load bank connectors shall be Camlok style mounted on gland plate.
1. Camlok shall be color coded according to system voltage
 - a. A phase: Black (208/120V) or Brown (480/277V)
 - b. B phase: Red (208/120V) or Orange (480/277V)
 - c. C phase: Blue (208/120V) or Yellow (480/277V)
 - d. G Ground: Green
- G. Temporary connectors shall include protective flip lids to prevent accidental contact.
- H. Permanent connectors shall be broad range set-screw type, located behind an aluminum barrier.
- I. Short Circuit & Withstand Rating
1. 65kAIC minimum, unless otherwise indicated on drawings.
- J. Voltage:
- K. 480/277V Current Rating:
1. As indicated on Drawings
- L. Phase Rotation Monitor Device:
1. Phase monitoring relay to be Siemens 3U4512-1AR20 or equal.
- M. Circuit Breakers:
1. UL 489 Listed
 2. Circuit breakers shall be removable for service and maintenance
 3. Circuit breakers rated 1200A or greater shall contain a maintenance mode switch which complies with NFPA 70 Article 240 arc energy reduction requirements. The maintenance mode switch shall temporarily modify the trip settings of the circuit breaker to reduce the available arc energy downstream of the circuit breaker.
 4. Circuit breakers for load bank connectors shall have a shunt trip coil, and shall be wired to trip the circuit breaker when a start signal is received from the transfer switch.
- N. Additional accessories shall be included in submittal drawings as follows:
1. Two-wire auto-start
 2. Battery charger receptacle, NEMA 5-20R, GFCI
 3. Block heater receptacle
 4. Extra-depth for bottom conduit entry.
 5. Kirk key door interlock
 6. Strip heater and thermostat
 7. Surge protection device
 8. Load dump receptacle
 9. Utility light.

10. Alarm contacts to indicate that the permanent emergency source is disconnected from the emergency system. Contacts shall change state when the generator feed circuit breaker is in the open position.

2.3 ALARM PANEL

- A. Description: Annunciator/alarm panel to indicate that the permanent emergency source is disconnected from the emergency system
- B. Features:
 1. Enclosure: Steel, flush or surface mountable
 2. Indicating Light: Red LED
 3. Buzzer
 4. Silence Button
 5. Operating Voltage: 120VAC

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.

3.2 INSTALLATION

- A. Surface, Flush or Base Mounted: Determined by Application
 1. Concrete bases: 4 inches high above finished grade, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of the enclosure. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems." Install anchor bolts to elevations required for proper attachment to Generator Docking Station.
- B. Power Wiring: Make connections to power distribution system as indicated on Drawings. Install wiring as required by Section 26 0519: "Low Voltage Power Conductors and Cables."
- C. Control Wiring: Install wiring as required by Section 26 0519: "Low Voltage Power Conductors and Cables."
 1. Start Circuit: Provide 2-wire start circuit wiring to the emergency system transfer switch(es) for installations where the generator docking station is connected to the emergency power system. Terminate 2-wire start circuit wiring at a terminal block inside generator docking station and label "Generator Start Circuit."
 2. Alarm Panel: Provide wiring from the docking station to the alarm panel. Where the alarm panel requires an external power source, provide a dedicated 120V circuit from a spare circuit breaker in the nearest panelboard.

3.3 FIELD QUALITY CONTROL

- A. Tests and Inspections to include the following:
 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

- B. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes test and inspection results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 4113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes lightning protection system for ordinary structures.
- B. Section includes lightning protection system for the following:
 - 1. Ordinary structures.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
 - 2. Include raceway locations needed for the installation of conductors.
 - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Lightning protection cabling attachments to roofing systems and accessories.
 - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
 - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- B. Qualification Data: For Installer.
- C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
- D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For lightning protection system to include in maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 01 7839 "Project Record Documents."

- b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

- B. Completion Certificate:
 - 1. UL Master Label Certificate.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advanced Lightning Technology, Ltd.
 - 2. East Coast Lightning Equipment Inc.
 - 3. ERICO International Corporation.
 - 4. Harger Lightning & Grounding.
 - 5. Heary Bros. Lightning Protection Co. Inc.
 - 6. Hicks Lightning Protection.
 - 7. Independent Protection Co.
 - 8. National Lightning Protection.
 - 9. Preferred Lightning Protection.
 - 10. Robbins Lightning, Inc.
 - 11. Insert manufacturer's name.

2.2 PERFORMANCE REQUIREMENTS

- A. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- B. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.

2.3 MATERIALS

- A. Air Terminals:
 - 1. Copper unless otherwise indicated.
 - 2. 3/8-inch (10-mm) diameter by 12 inches (305 mm) long.
 - 3. Rounded tip.
 - 4. Threaded base support.
- B. Air Terminal Bracing:
 - 1. Copper.
 - 2. 1/4-inch (6-mm) diameter rod.
- C. Class II Main Conductors:
 - 1. Stranded Copper: 115,000 circular mils in diameter.
- D. Secondary Conductors:

1. Stranded Copper: 26,240 circular mils in diameter.
- E. Ground Loop Conductor: Tinned copper.
- F. Ground Rods:
 1. Material: Solid copper .
 2. Diameter: 5/8 inch (16 mm) .
 3. Rods shall be not less than 120 inches (3050 mm) long.
- G. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A.
 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
 2. Install conduit where necessary to comply with conductor concealment requirements.
 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: exothermic weld .
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Perform inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

END OF SECTION

FOR REFERENCE ONLY

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
 - 1. Section 26 2416 "Panelboards" for factory-installed SPDs.

1.2 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB.
 - 2. Eaton Corporation.
 - 3. LEA International; Protection Technology Group.
 - 4. Leviton Manufacturing Co., Inc.
 - 5. PowerLogics, Inc.
 - 6. Schneider Electric Industries SAS.
 - 7. Siemens Industry, Inc.
 - 8. Raycap, Inc.

2.2 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 115 percent of the nominal system voltage.

2.3 PANEL SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 2.
 - 1. Include LED indicator lights for power and protection status.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. Comply with UL 1283.

- D. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V and 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 2. Line to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 3. Neutral to Ground: 1200 V for 480Y/277 V, 700 V for 208Y/120 V.
 4. Line to Line: 2000 V for 480Y/277 V, 1200 V for 208Y/120 V

E. SCCR: Equal or exceed 100 kA.

F. Inominal Rating: 20 kA 10 kA.

2.4 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 1.

B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1.

B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.

C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

D. Use crimped connectors and splices only. Wire nuts are unacceptable.

E. Wiring:

1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DEFINITIONS

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. LED: Light-emitting diode.
- E. LER: Luminaire efficacy rating.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting fixture, including ballast housing if provided.
- H. L70: Point in time where light fixture lumen output is 70% of initial light output.
- I. McAdams Ellipses: Color consistency of LED's from chip to chip.

1.2 SUBMITTALS

- A. Refer to Sections 012500 "Substitution Procedures" and 013300 "Submittal Procedures."
- B. Product Data: For each type of lighting fixture, arranged in order of fixture designation as listed on the fixture schedule. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.
 - 2. Emergency lighting units including battery and charger.
 - 3. Ballast, including BF.
 - 4. Energy-efficiency data.
 - 5. Lamp data: rated life, lumen output, CCT, CRI and wattage.
 - 6. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, and Grilles."
 - 7. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
- C. Photometric Data Submittals
 - 1. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, for the following lighting fixture types. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.

- b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 2. Include the following in the photometric report:
 - a. List the measured candela values of the photometric distribution in at least three planes, except in the case of an axially symmetrical lighting fixture. Candela curves, lux (footcandle) and lumen tables, and iso-lux (iso-footcandle) contours are not acceptable.
 - b. List the type of lamps, ballasts, and lighting control devices, such as lenses and louvers, used with the tested lighting fixture.
- D. Shop Drawings: For nonstandard or custom lighting fixtures as indicated on the fixture schedule. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- E. Samples: Production run samples for each lighting fixture in the Interior Lighting Fixture Schedule indicated for sample. Each Sample shall include the following:
 - 1. Lamps and 120-volt ballasts, installed.
 - 2. Minimum 6-foot cords and NEMA configured, grounded, straight blade plug for 120-volt operation plugs.
 - 3. Pendant support system.
- F. Installation instructions.
- G. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Lighting fixtures.
 - 2. Suspended ceiling components.
 - 3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches (305 mm) of the plane of the luminaires.
 - 4. Ceiling-mounted projectors.
 - 5. Structural members to which suspension systems for lighting fixtures will be attached.
 - 6. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Sprinklers.
 - d. Smoke and fire detectors.
 - e. Occupancy sensors.
 - f. Access panels.
 - 7. Perimeter moldings.
- H. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- I. Product Certificates: Compatibility for each type of ballast for bi-level and dimmer-controlled lamps and fixtures as specified, from manufacturer.

- J. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

- K. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.
- E. Provide fixtures U.L. listed and labeled for the application.
- F. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- G. Mockups: Provide interior lighting fixtures for room or module mockups, complete with power and control connections.
 - 1. Obtain Architect's approval of fixtures for mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approved fixtures in mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.4 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.5 WARRANTY

- A. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Emergency Lighting Unit Batteries: [10] **<Insert number>** years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

- B. Special Warranty for LED Lighting Fixtures: Manufacturer's standard form in which manufacturer of lighting fixture agrees to repair or replace components, including driver/power supplies and thermal management, that fail in materials or workmanship within five years date of substantial completion.

1.6 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps: **[10 for every 100] <Insert quantity>** of each type and rating installed. Furnish at least one of each type.
 2. Plastic Diffusers and Lenses: **[One for every 100] <Insert quantity>** of each type and rating installed. Furnish at least one of each type.
 3. Emergency battery pack: One for every **[20] [50] <Insert number>** emergency lighting unit.
 4. LED Drivers: **[One for every 100] <Insert quantity>** of each type and rating installed. Furnish at least one of each type.
 5. Globes and Guards: **[One for every 20] <Insert quantity>** of each type and rating installed. Furnish at least one of each type.

1.7 ALLOWANCES

- A. Extra Fixtures
1. Provide an additional **[5] [10] [...]** exit signs, Type **["X1"] [...]** above what is indicated on the drawings. Include for each of the extra units, installation of 75 feet of conduit and wire, and connection to the emergency system.
 2. Install devices at locations to be determined by the Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, **[provide product by manufacturers indicated on Drawings and specified.]**

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.
- C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
- D. LED Fixtures: Minimum rated lifetime of L70 at 50,000 hours based on IES LM-79 testing; passive thermal management only unless otherwise indicated.
- E. Metal Parts: Free of burrs and sharp corners and edges.

- F. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- G. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.
- H. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least [**0.125 inch (3.175 mm)**] <Insert dimension> minimum unless otherwise indicated.
 - b. Distribution: [**Pattern 12**] [**Pattern 19**] [**Pattern 20**] [as indicated]
 - c. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- I. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp and ballast characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
 - d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
 - e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
- J. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. General Requirements for Electronic Ballasts:
 - 1. Comply with UL 935 and with ANSI C82.11.
 - 2. Designed for type and quantity of lamps served.
 - 3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
 - 4. Starting type: [**programmed rapid-start**] [**rapid-start**] [**instant-start**] unless otherwise indicated.
 - 5. Sound Rating: Class A.
 - 6. Total Harmonic Distortion Rating: Less than [**10**] [**20**] percent.
 - 7. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 - 8. Operating Frequency: [**42**] <Insert value> kHz or higher.
 - 9. Lamp Current Crest Factor: 1.7 or less.
 - 10. BF: 0.92 for T8 lamps, 1.0 for T5 lamps, and 0.88 for T4 lamps, or higher.

11. Power Factor: 0.95 lagging or higher.
 12. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- B. Luminaires controlled by occupancy sensors shall have programmed-start ballasts.
- C. Electronic Programmed-Start Ballasts for T5, T5HO and T8 Lamps: Comply with ANSI C82.11 and the following:
1. Lamp end-of-life detection and shutdown circuit for T4 and T5 diameter lamps.
 2. Automatic lamp starting after lamp replacement.
- D. Electromagnetic Ballasts: Comply with ANSI C82.1; energy saving, high-power factor, Class P, and having automatic-reset thermal protection.
1. Ballast Manufacturer Certification: Indicated by label.
- E. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- F. Ballasts for Low-Temperature Environments:
1. Temperatures 0 Deg F (Minus 17 Deg C) and Higher: [**Electronic**] [or] [**electromagnetic**] type rated for 0 deg F (minus 17 deg C) starting and operating temperature with indicated lamp types.
 2. Temperatures Minus 20 Deg F (Minus 29 Deg C) and Higher: Electromagnetic type designed for use with indicated lamp types.
- G. Ballasts for Residential Applications: Fixtures designated as "Residential" may use low-power-factor electronic ballasts having a Class B sound rating and total harmonic distortion of approximately 30 percent.
- H. Ballasts for Low Electromagnetic-Interference Environments: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for consumer equipment.
- I. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
1. Dimming Range: 100 to [5] <Insert number> percent of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to [20] <Insert number> percent of normal.
 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
 4. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.
- 2.4 LED MODULES/BOARDS
- A. Minimum rated lifetime of L70 at 50,000 hours based on IES LM-80 testing; 4-step McAdams Ellipse maximum color consistency unless otherwise indicated; 80 CRI minimum unless otherwise indicated.

2.5 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 - 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.
- C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 - g. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
- 2. Master/Remote Sign Configurations:
 - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in [LED power supply] [ballast] [battery] for power connection to remote unit.
 - b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.
- D. Self-Luminous Signs: Powered by tritium gas, with universal bracket for flush-ceiling, wall, or end mounting. Signs shall be guaranteed by manufacturer to maintain the minimum brightness requirements in UL 924 for [10] [15] [20] years.
- E. Self-Luminous Signs: Using strontium oxide aluminate compound to store ambient light and release the stored energy when the light is removed. Provide with universal bracket for flush-ceiling, wall, or end mounting.

2.6 EMERGENCY LIGHTING UNITS

- A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.
 - 1. Battery: Sealed, maintenance-free, lead-acid type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.

3. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. Wire Guard: Heavy-chrome-plated wire guard protects lamp heads or fixtures.
7. Integral Time-Delay Relay: Holds unit on for fixed interval of [15] <Insert period> minutes when power is restored after an outage.
8. Remote Test: Switch in hand-held remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.7 FLUORESCENT LAMPS

- A. Products subject to compliance with requirements provide lamps from one of the following manufacturers:
 1. GE Company, GE Lighting
 2. OSRAM Sylvania Inc.
 3. Philips Lighting
- B. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches (1220 mm), 2800 initial lumens (minimum), CRI [75][85] (minimum), color temperature [3500] <Insert value> K, and average rated life 20,000 hours unless otherwise indicated.
- C. T8 rapid-start lamps, rated 17 W maximum, nominal length of 24 inches (610 mm), 1300 initial lumens (minimum), CRI [75][85] 75 (minimum), color temperature [3500] <Insert value> K, and average rated life of 20,000 hours unless otherwise indicated.
- D. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches (1150 mm), 2900 initial lumens (minimum), CRI 85 (minimum), color temperature [3500] <Insert value> K, and average rated life of 20,000 hours unless otherwise indicated.
- E. T5HO rapid-start, high-output lamps, rated 54 W maximum, nominal length of 45.2 inches (1150 mm), 5000 initial lumens (minimum), CRI 85 (minimum), color temperature [3500] <Insert value> K, and average rated life of 20,000 hours unless otherwise indicated.

2.8 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General
 1. Install lighting systems in accordance with NECA/IESNA 500, 501 and 502.
 2. Assemble and install lighting fixtures in a manner to insure a straight and true installation without dents, warps, and other irregularities.
 3. Where lighting fixtures are specified or indicated for installation in continuous rows, install fixtures in a continuous end-to-end manner without gaps between fixture segments, and with vertical and horizontal variations, along the length of the continuous installation, no greater than 6 mm (1/4 inch).
 4. Coordinate the lighting system installation with relevant trades so as to eliminate installation interferences, such as with hangers, mechanical ducts, sprinklers, piping and steel structure.
 5. Install lighting fixtures in a common area space so that the orientation of the lens and louver door latches and hinges are in the same direction.
 6. Provide plaster frames for recessed fixtures installed in other than suspended grid ceiling systems.
- B. Lighting fixtures:
 1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 2. Install lamps in each luminaire.
- C. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- D. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.
- E. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires for each fixture [, **independent of the ceiling suspension devices**,]. Locate not more than 6 inches (150 mm) from lighting fixture corners. Do not use steel roof decking for light fixture supports; provide additional steel to building structure to provide a suitable support for light fixture support wires.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

F. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure. Do not use steel roof decking for light fixture supports; provide additional steel to building structure to provide a suitable support for light fixture support wires.
5. Install suspended lighting fixtures at mounting heights specified or indicated, plus or minus 6 mm (1/4-inch).

G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 CLEANING

- A. Clean interior surfaces of lighting fixtures of dirt and construction debris upon completion of installation. Clean fingerprints, smudges, and other marks from lenses, louvers, and reflecting surfaces. Leave free of visible marks.

3.5 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust the lamp socket position in downlight lighting fixtures per the manufacturer's recommendations for the specified lamp type and voltage. Optimize the lighting output of the lighting fixture by properly locating the light center within the reflector.
 - 2. Upon final completion of the installation of the lighting fixtures and any associated lighting control systems, notify the Architect in writing to arrange for the final adjustment and aiming of lighting equipment requiring aiming and adjustment.
 - 3. Adjust aimable luminaires in the presence of Architect and Lighting Designer.

END OF SECTION

SECTION 26 5600 - EXTERIOR LIGHTING**PART 1 - GENERAL****1.1 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION**

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.
- C. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.
- D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
 - 1. Basic wind speed for calculating wind load for poles exceeding 49.2 feet (15 m) in height is [100 mph (45 m/s)] [90 mph (40 m/s)] **<Insert value from AASHTO LTS-4-M>**.
 - a. Wind Importance Factor: **[1.0] <Insert value from Table 3-2>**.
 - b. Minimum Design Life: **[50 years] <Insert value from Table 3-3>**.
 - c. Velocity Conversion Factors: **[1.0] <Insert value from Table 3-2>**.
 - 2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is [100 mph (45 m/s)] [90 mph (40 m/s)] **<Insert value from AASHTO LTS-4-M for this Project>**.
 - a. Wind Importance Factor: **[1.0] <Insert value from Table 3-2>**.
 - b. Minimum Design Life: **[25 years] <Insert value from Table 3-3>**.
 - c. Velocity Conversion Factors: **[1.0] <Insert value from Table 3-2>**.

1.2 ACTION SUBMITTALS

- A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, and finishes.
 - 1. Lamps, including life, output (lumens, CCT, and CRI) and energy-efficiency data.
 - 2. Photometric data and adjustment factors based on laboratory tests, complying with **[IES LM-79][IES LM-80]**
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficiency Lighting Products.
 - b. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
 - 3. Wiring diagrams for power, control, and signal wiring.
 - 4. Photoelectric relays.
 - 5. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
- B. Shop Drawings:
 - 1. For nonstandard or custom luminaires.
 - a. Include plans, elevations, sections, and mounting and attachment details.

- b. Include details of luminaire assemblies. Include dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - c. Include diagrams for power, signal, and control wiring.
- 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective cover prior to shipping.

1.6 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of the luminaire installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide product indicated on Drawings.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
- B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- G. Exposed Hardware Material: Stainless steel.
- H. Internal driver.
- I. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- J. L70 lamp life of 50,000 hours.
- K. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- L. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.
- M. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- N. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- O. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- P. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected by Architect from manufacturer's standard catalog of colors or as indicated on Drawings.
- Q. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: **[Light bronze] [Medium bronze] [Dark bronze] [Black]**.
- 2.3 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS
- A. Comply with UL 773 or UL 773A.
 - B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. **[Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.]**
 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
 2. Adjustable window slide for adjusting on-off set points.
- 2.4 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS
- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of **[1.1] <Insert number>** to obtain the equivalent projected area to be used in pole selection strength analysis.
 - B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws. [**Provide on all, except wood poles.**]
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 03 3000 "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.5 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 - 1. Shape: [**Round, tapered**] [**Round, straight**] [**Square, tapered**] [**Square, straight**].
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Steel Mast Arms: [**Single-arm**] [**Truss**] [**Davit**] type, continuously welded to pole attachment plate. Material and finish same as pole.
- C. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 - 1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with [**stainless**] [**galvanized**]-steel bolts.
 - 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 - 3. Match pole material and finish.
- D. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- E. Steps: Fixed steel, with nonslip treads, positioned for 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole; first step at elevation 10 feet (3 m) above finished grade.
- F. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

- G. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- H. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- I. Galvanized Finish: After fabrication, hot-dip galvanize complying with ASTM A 123/A 123M.
- J. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
 - 2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 - 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: **[As indicated by manufacturer's designations] [Match Architect's sample] [As selected by Architect from manufacturer's full range].**

2.6 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: **[Round, tapered] [Round, straight] [Square, tapered] [Square, straight].**
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 - 1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - 2. Finish: Same as **[pole] [luminaire].**
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
5. **<Insert finish>**.
 - a. Color: **[Light bronze] [Medium bronze] [Dark bronze] [Black] [As selected by Architect from manufacturer's full range]**.

2.7 WOOD POLES

- A. Poles: **[Douglas fir] [Southern yellow pine]**, **[machine trimmed by turning]**, complying with ANSI O5.1 and with AWPA C4 for wood species used; and bored, roofed, and galled before treatment.
 1. Mounting Provisions: Embedded.
- B. Preservative Treatment: Pressure treat poles with **[creosote] [pentachlorophenol] [ammoniacal copper arsenate]** according to AWPA C1 and AWPA C4.
- C. Luminaire Brackets: Comply with ANSI C136.13.

2.8 POLE ACCESSORIES

- A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Section 26 2726 "Wiring Devices" for ground-fault circuit-interrupter type.
 1. **[Surface mounted] [Recessed]**, [12 inches (300 mm)] **<Insert dimension>** above finished grade.
 2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, **<Insert color to match pole,>** that when mounted results in NEMA 250, **[Type 3R] [Type 4X]** enclosure.
 3. With cord opening.
 4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept **[ballast(s)] [indicated accessories]**.
- E. Decorative accessories, supplied by decorative pole manufacturer, include the following:
 1. Banner Arms: **<Insert material>**.
 2. Flag Holders: **<Insert material>**.
 3. Ladder Rests: **<Insert material>**.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. [**Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.**]

3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
 - 1. Fire Hydrants and Storm Drainage Piping: [60 inches (1520 mm)] **<Insert dimension>**.
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: [10 feet (3 m)] **<Insert dimension>**.
 - 3. Trees: [15 feet (5 m)] **<Insert dimension>** from tree trunk.
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 03 3000 "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - 1. Dig holes large enough to permit use of tampers in the full depth of hole.
 - 2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
- F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - 1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.

2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.
 3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
 4. Cure concrete a minimum of 72 hours before performing work on pole.
- G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with **[pea gravel]** **<Insert material>** to a level 1 inch (25 mm) below top of concrete slab.
- H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top [4 inches (100 mm)] **<Insert dimension>** above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 3000 "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. Install on concrete base with top [4 inches (100 mm)] **<Insert dimension>** above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 03 3000 "Cast-in-Place Concrete."
- B. Remote Mounting of Drivers/Power Supplies: Do not exceed the manufacturer's recommended maximum distance between the fixture and the driver/power supply.

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 26 0533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

- A. Ground metal poles and support structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
1. Install grounding electrode for each pole unless otherwise indicated.
 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Section 26 0526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.
2. Install grounding conductor and conductor protector.
3. Ground metallic components of pole accessories and foundations.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 1. Adjust the lamp socket position in downlight lighting fixtures per the manufacturer's recommendations for the specified lamp type and voltage. Optimize the lighting output of the lighting fixture by properly locating the light center within the reflector.
 2. Upon final completion of the installation of the lighting fixtures and any associated lighting control systems, notify the Architect in writing to arrange for the final adjustment and aiming of lighting equipment requiring aiming and adjustment.
 3. Adjust aimable luminaires in the presence of Architect and Lighting Designer.

END OF SECTION

FOR REFERENCE ONLY

SECTION 27 0500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide all materials and labor for the installation of an inside plant telecommunication system. All materials shall be new, free from defects, of current manufacture, of the quality specified or shown. Each type of material shall be of the same manufacturer throughout the work. This section includes Inside Plant Communications cabling, termination, and administration equipment and installation requirements for the specified Structured Cabling System.
- B. This section specifies the basic requirements for communications installations as indicated or required and includes requirements common to more than one specification section of this division (such as related documents, related sections, definitions, governing requirements, contractor requirements, warranty requirements, submittal requirements/procedures, and project closeout requirements/procedures, as well as other requirements). This section may expand upon and/or supplement the requirements specified in Division 01.
- C. Examine the contract documents in their entirety (including drawings and specification sections in the other divisions) for requirements or work which may affect work under this section, regardless of whether such requirements or work are specifically indicated in this section.

1.2 DEFINITIONS AND ABBREVIATIONS

- A. ANSI – American Northern Standards Institute
- B. AVC - Audiovisual Contractor
- C. AWG – American Wire Gauge
- D. BICSI – Building Industry Consulting Service International
- E. BCT – Bonding Conductor for Telecommunications
- F. CL - Client
- G. EC - Electrical Contractor
- H. EIA – Electronics Industry Alliance
- I. ETL – Intertek Certification Services
- J. GC - General Contractor
- K. IEC – International Electrotechnical Commission
- L. IEEE – Institute of Electrical and Electronic Engineers
- M. IDC – Insulation displacement contact
- N. ISO – International Standards Organization
- O. NECA – National Electrical Contractors Association
- P. NFPA – National Fire Protection Agency
- Q. NRTL – Nationally Recognized Testing Laboratory
- R. STC - Sound Transmission Class

- S. TIA – Telecommunications Industry Association
- T. TC - Telecommunications Contractor
- U. UL – Underwriters Laboratory
- V. Provide: Furnish, install, terminate, label, test and certify a complete operating cabling system.
- W. Contract Documents (CD): Design drawings, specifications, sketches and schedules provided by the Engineer as they directly relate to this scope of work and this project.
- X. Structured Cabling Systems (SCS) wiring is defined as all required equipment and cabling including hardware, termination blocks, cross connect wire or cordage, patch panels, patch cords, telecommunication outlets, work area cords, UTP and fiber cable installed and configured to provide computer data and voice connectivity.
- Y. Network Center/Main Distribution Frame (MDF) Areas: This technology space houses Layer 2/3 network switching gear and other main network distribution equipment and acts as the mid-connection point between the Core/Network and the TR/IDF/access zones for all connections.
- Z. Telecommunications Room (TR)/Intermediate Distribution Frame (IDF): is the location for the termination of backbone cables and for termination of horizontal cables, and for the interconnection of each. The space also hosts access-layer switches and user network connections within each floor.
- AA. Active Equipment: electronic equipment used to develop various WAN, LAN, and voice services, e.g., digital multiplexers, RS-232 controllers, Ethernet hubs, switches, routers, PBX, etc.
- BB. Building Backbone: cabling system consisting of media and termination hardware interconnecting MDFs to IDFs.
- CC. Horizontal: cabling system consisting of media and termination hardware interconnecting the Telecommunication Outlets (TOs) and the TRs.
- DD. Bonding: permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed on it.
- EE. Cable Tray: vertical or horizontal open supports, usually made of aluminum or steel, which are fastened to the building structure. Cables are laid in and fastened to the trays.
- FF. Cabinet: free standing, floor-mounted or wall-mounted modular enclosure designed to house and protect rack-mounted electronic equipment and passive terminations.
- GG. Channel: The end-to-end transmission path between two points at which application specific equipment is connected; encompasses all the elements of the horizontal cabling link, plus the equipment cords in the telecommunications spaces and work area.
- HH. Cross-Connect: equipment used to terminate and tie together communications circuits.
- II. Cross-Connect Jumper: a cluster of twisted-pair conductors without connectors used to establish a circuit by linking two cross-connect termination points.
- JJ. Grounding: a conducting connection to earth, or to some conducting body that serves in place of earth.
- KK. Jack: receptacle used in conjunction with a plug to make electrical contact between communications circuits, e.g., eight-position/eight-contact modular jacks.

- LL. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
- MM. LAN: Local area network.
- NN. Link: Horizontal cabling link encompassing all components of the horizontal cabling (TO, patch panels, blocks, jumpers and patch cords that join them in the horizontal cross-connect). It is distinguished from a channel because it does not include the equipment cables/cords at the telecom spaces or work area.
- OO. Media: twisted-pair, and fiber optic cable or cables used to provide signal transmission paths.
- PP. Mounting Frame: rectangular steel framework, which can be equipment rack or wall mounted to support wiring blocks, patch panels, and other communications equipment.
- QQ. Outside Plant (OSP): generally, any and all portions of the cable system that runs outside of an environmentally enclosed structure and/or building with each end terminated at different buildings. This specifically includes inter-building cables, conduits, manholes, hand-holes, and innerduct.
- RR. UTP: Unshielded Twisted Pair.
- SS. FO: Fiber Optic
- TT. Passive Equipment: non-electronic hardware and apparatus, e.g., equipment racks, cable trays, electrical protection, patch panels, wiring blocks, fiber optic shelves, etc.
- UU. Patch Cords: a length of wire or fiber cable with connectors on one or both ends used to join communications circuits at a cross-connect.
- VV. Patch Panel: system of terminal blocks or connectors used with patch cords that facilitate administration of cross-connect fields.
- WW. Pathway: facility for the placement of communications cable. A pathway facility can be composed of several components including conduit, wireway, cable tray, surface raceway, under floor systems, overhead systems, raised floor, ceiling support wires, etc.
- XX. Protectors: electrical protection devices used to limit foreign voltages on metallic communications circuits.
- YY. Raceway: an enclosed channel designed expressly for holding wires or cables; may be of metal or insulating material. The term includes conduit, tubing, wire ways, under floor raceways, overhead raceways and surface raceways; does not include cable tray.
- ZZ. Racks: An open, freestanding, floor-mounted structure, typically made of aluminum or steel, used to mount equipment; usually referred to as an equipment rack.
- AAA. Riser Backbone: The Riser Backbone subsystem links the main cross connect (MDF) in the equipment room to the distribution rooms (TRs).
- BBB. Structured Cabling System (SCS): A SCS is defined as all required cabling including hardware, termination blocks, cross connect wire or cordage, patch panels, patch cords, telecommunication outlets, work area cords, UTP and fiber optic cable installed and configured to provide computer data and voice connectivity from each data or voice device to the network file server or voice network/switch designated as the service point of the local area network.
- CCC. Telecommunication Outlet (TO): Connecting device mounted in a work area used to terminate horizontal cable and interconnect cabling with station equipment.

- DDD. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
- EEE. Work Area Subsystem: The connection between the telecommunications outlet and the station equipment in the work area is provided by the Work Area Subsystem. It consists of cords, adapters, and other transmission electronics.
- FFF. Wireless Access Point (WAP): Telecom outlet designated for use with wireless network devices. Such outlet shall be mounted above the ceiling.
- GGG. Contractor – The successful bidder engaged to provide the work of this specification.

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.
- B. Related Documents and Sections:
1. Section 00 00 00 – Procurement and Contracting Requirements
 2. Section 01 00 00 – General Requirements
 3. Section 27 05 00 – Common Work Results for Communications
 4. Section 27 05 26 – Grounding and Bonding for Communications Systems
 5. Section 27 05 28 – Pathways for Communications Systems
 6. Section 27 05 33 – Conduit for Communications Systems
 7. Section 27 05 53 – Identification for Communication Systems
 8. Section 27 11 00 – Communications Equipment Room Fittings
 9. Section 27 11 16 – Communications Cabinets, Racks, Frames and Enclosures
 10. Section 27 13 00 – Communications Backbone Cabling
 11. Section 27 15 00 – Communications Horizontal Cabling
 12. Section 27 17 00 – Testing of Structured Cabling Systems
- C. The following codes, associations, acts and agencies, as required by law:
1. National Electric Codes (NEC) – all applicable
 2. OSHA Standards and Regulations – all applicable
 3. Local Codes and Standards – all applicable
 4. Codes and Guidance of the Local Authority Having Jurisdiction (AHJ)
- D. The current edition of the following standards:
1. BICSI Telecommunications Distribution Methods Manual (TDMM)
 2. BICSI Outside Plant Design Reference Manual (OSPDRM)
 3. BICSI Information Technology Systems Installation Methods Manual (ITSIMM)
 4. ANSI/TIA 568 series, most recent revisions, addenda, and systems bulletins. All applicable
 5. ANSI/TIA–569 Telecommunications Pathways and Spaces, most recent revision including all relevant addenda and systems bulletins
 6. ANSI/TIA–606 Administration Standard for Telecommunications Infrastructure, most recent revision including all addenda and systems bulletins
 7. ANSI/TIA–607 Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises, most recent revision including all addenda and systems bulletins
 8. ANSI/TIA–862 Structured Cabling Infrastructure Standard for Intelligent Building Systems, most recent revision including all addenda and systems bulletins

9. ANSI/TIA-942 Telecommunications Infrastructure Standard for Data Centers, most recent revision including all addenda and systems bulletins
10. ANSI/TIA-1179 Healthcare Facility Telecommunications Infrastructure Standard, most recent revision including all addenda and systems bulletins
11. ANSI/TIA-4966 Telecommunications Infrastructure Standard for Educational Facilities, most recent revision including all addenda and systems bulletins
12. UL444 – Standard for Safety of Communications Cable
13. UL 1666 – Standard for Safety of Flame Propagation Height
- E. The current edition of the following guidelines:
 1. TIA-TSB-162 Telecommunications Cabling Guidelines for Wireless Access Points, most recent revision including all addenda and systems bulletins
- F. When a discrepancy arises between the above-mentioned codes, standards or guidelines and the standards contained in this document, it shall be brought to the attention of the Owner immediately for resolution. The more stringent of the two guidelines shall be implemented.
- G. Any violations of applicable standards or codes committed by the Contractor shall be remedied at the Contractor's expense

1.4 SYSTEM DESCRIPTION

- A. Furnish, install, test and place into satisfactory and successful operation all equipment, materials, devices, and necessary appurtenances to provide a complete communications system that is compliant with ANSI/TIA/EIA, NECA/NEIS and ISO/IEC standards as hereinafter specified and/or shown on the Contract Documents. The system is intended to be capable of integrating voice, data, and video signals onto a common media.
 1. The Structured Cabling System shall be tested for 10 Gigabit Ethernet operation for all Category 6A as specified in the most recent edition of IEEE 802.3 and its related amendments.
- B. The work shall include all materials, equipment and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant SCS.

1.5 SUBMITTALS

- A. Make submittals in accordance with:
 1. Section 00 00 00 – Procurement and Contracting Requirements
 2. Section 01 33 00 – Submittal Procedures.
- B. Action Submittals:
 1. Shop Drawings – RCDD stamped
 - a. Electronic files in CAD format, containing the contract document drawing files will be provided, for use in the preparing of the shop drawings, by the RCDD.
 - b. Submit Overall Floor Plans: floor and site plans showing the locations of devices and cable routing paths with cable types and quantity called out.
 - c. Submit Shop drawings for the entire structured cabling system and grounding and bonding system, identifying such items as PBB, SBB, TBB, rack fills, cabling pathways and pathway fills, ladder and other cable raceways, coordination with other trades, etc.
 - d. Wiring diagrams

- e. Rack Elevation drawings
- 2. Product Data Submittals: Provide submittal information for review before materials are delivered to the job site. Provide product data submittals for all products at the same time.
 - a. Submit a letter stating that the materials will be provided as specified, and specifically listing any items that will not be provided as specified. The letter shall also state that the Contractor has reviewed the specified items and agrees that they are applicable to this project in all respects.
 - b. For those items noted as allowing “or equal,” and which are not being provided as specifically named, submit standard manufacturer's cut sheets or other descriptive information, along with a written description detailing the reason for the substitution.
 - c. Provide standard manufacturer's cut sheets and the operating and maintenance (O&M) instructions at the time of submittal review for each device in the system, regardless of whether it is submitted as specified or as an approved equal. These instructions shall detail how to install and service the equipment and shall include information necessary for rough-in and preparation of the building facilities to receive the materials.
 - d. Catalog cut sheets and data sheets containing physical and dimensional information, performance data, electrical characteristics, materials used in fabrication, and material finish. Clearly indicate on each sheet what is being submitted on.
- 3. Qualification Data
 - a. Submit at least three references for telecommunications cabling jobs already completed, involving both fiber optics and twisted pair cabling, similar in scope to the project described herein. Include, for each customer reference, the following information: Company name, address, phone number, name and email address of contact and type of job completed.
- 4. Provide all applicable portions of the following information for sections listed in paragraph 1.03-C above, in addition to the standard requirements, within 7 days after receiving each reel and/or box of cable:
 - a. Manufacturer's product test data for fiber optic cable components.
 - b. Visually inspect Category 6A UTP. Materials cannot be used before results have been submitted to CM and approved by the Owner or its representative.
 - c. On-reel OTDR testing of all fiber.
- 5. Provide all applicable portions of the following completed test documentation for sections listed in paragraph 1.03-C above, in addition to the standard requirements, within 10 days after completion of the tests for each cable channel or link:
 - a. Test reports shall be submitted in the following manner:
 - 1) To the Owner: One copy on eight and one-half inch by eleven papers providing for quality reproducible printing, and electronic copy in MS Excel format.
 - 2) Submit test report documentation through CM for review by the Engineer for specification conformance and one copy in electronic format.
 - b. Twisted-pair field test documentation
- C. Closeout Submittals

1. Final close out documents including, but not limited to, test results on a CD-ROM or USB drive, in native tester format, project manual that includes manufacturer and contractor warranties, product cut sheets, material submittals, etc. Also, include the following:
 - a. Hard copy documentation of test results for every cable segment and link in 3-ring binder.
 - b. Provide "As-Built" Drawings in same AutoCAD 2018 DWG format.
 - 1) "As-Built" drawings indicating the location of all equipment including but not limited to work area outlets, patch panels, cross connect blocks, on each segment and cable routing outlet and identifiers. Indicate labeling for each piece of equipment.
 - 2) As-Built drawings will contain all installed cabling and materials. Outlets will be numbered with each cable associated with the work area outlet.
 - c. Place a laminated full-size, minimum "C" sized, floor plan of these drawings (coordinate with Owner) on the wall of each communications room, showing area covered, data locations, and cable labeling

1.6 QUALITY ASSURANCE

- A. Manufacturer's Warranty
 1. Contractor shall provide an extended manufacturer's warranty on all copper and fiber links and/or channels.
 2. The Contractor will correct any problems and malfunctions that are warranty-related issues without charge for the entire warranty period.
 3. The warranty period shall commence following the final acceptance of the project by the Owner.
- B. Testing and Inspection of Communications Equipment
 1. Provide tests specified below, when applicable, and as indicated under individual items of material, equipment, and work specified in this Specification.
 - a. Furnish all test equipment and instruments required for the tests.
 - b. Responsible, qualified employees of the contractor in the presence of the Owner or an authorized representative shall perform the cable testing.
 - c. All individuals involved in the testing phase of the project shall not have been involved in the installation phase nor shall have immediate knowledge of the installation task.
 2. End-to-end performance of all parts and channels will be tested.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, and work above ceilings is complete

1.8 RESPONSIBILITIES AND COORDINATION

- A. The contractor shall provide all materials, qualified labor and services required to ensure a complete and operational system, installed in accordance with the intent of the Contract Documents.

- B. The contractor shall furnish and install all incidental items not actually shown or specified, but which are required by best practices to provide complete functional systems.
- C. The contractor shall coordinate the details of facility equipment and construction for all specification divisions, which affect the work covered under this Division.
- D. The contractor shall coordinate all activities with the overall construction schedule.
- E. The contractor shall develop a bill of materials, perform material management and efficient use of the materials whether they are issued by Owner or purchased by the Contractor.
- F. The contractor shall ensure materials, in excess of, those required to complete the project are kept in their original condition and packaging for restocking.

1.9 DESIGN CRITERIA

- A. Compliance by the contractor with the provisions of this Specification does not relieve him or she from the responsibilities of providing materials and equipment of proper design, mechanically and electrically suited to meet operating requirements at the specified service conditions.
- B. The soliciting Owner seeks a state-of-the-art infrastructure for this new building. The design intends to achieve a technology infrastructure geared towards a complex environment. The design will also employ features applied at similar facilities and draw concepts from the new TIA-942 – Telecommunications Infrastructure Standard for Data Centers. Furthermore, the design will be of high reliability and offer manageable fault-tolerant topology.
- C. The following are incorporated into the design:
 - 1. The intent of the drawings is to restrict the maximum horizontal subsystem cabling length to 295 feet for all horizontal cabling.

1.10 LABELING

- A. Comply with TIA/EIA-606-A, TIA/EIA-606-A, Addendum 1 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Refer to Section 270553 – “Identification for Communications Systems”

PART 2 PRODUCTS

2.1 GENERAL

- A. This Section includes General Requirements for each section in Division 27 and shall be used in conjunction with specifications, other related Divisions, and related Contract Documents to establish the total requirements for the project:
 - 1. Refer to specific sections for Product Part Numbers.
- B. All products must be from the same manufacturer.

2.2 SUBSTITUTION POLICY

- A. Contractor shall assume all costs for removal and replacement of any product installed in substitution of those specified. Such costs shall include but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

PART 3 EXECUTION

3.1 WORKMANSHIP

- A. Manufactured products, materials, equipment, and components shall be provided, conditioned, applied, installed, connected, and tested in accordance with the manufacturer's specifications and printed instructions.
- B. The installation of all system components shall be carried out under the direction of qualified personnel. Appearance shall be considered as important as mechanical and electrical efficiency. Workmanship shall meet or exceed industry standards.
- C. All penetrations shall be sealed as required to maintain fire, smoke, and STC ratings.

3.2 INTENT OF DRAWINGS

- A. The technology drawings show only general locations of equipment, devices, raceways, cable trays, boxes, etc., unless specifically dimensioned.
- B. The contractor shall be responsible for the proper placement and routing of equipment, cable, raceways, cable runway, and related components, according to the Contract Documents and subject to prior review by the Owner and structured cabling engineer.
- C. The contractor shall refer any conflicts within the Contract Documents to the Construction Manager and/or Owner for resolution.

3.3 GROUNDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- B. Comply with ANSI/TIA-607 and the National Electrical Code.

3.4 FIRESTOPPING

- A. Comply with requirements in the National Building Code and the National Electrical Code.
- B. Comply with Section 07 84 00 "Penetration Firestopping".

3.5 SERVICE CONTINUITY

- A. Maintain continuity of communications services to all functioning portions of the process or buildings during hours of normal use.
- B. Arrange temporary outages for cutover work with CM. Keep outages to a minimum number and a minimum length of time in order to provide minimum impact.

3.6 LAYOUT AND TOLERANCES

- A. Follow as closely as practicable the schematic design shown on the drawings. Make all necessary measurements in the field to verify exact locations and ensure precise location and fit of specified items in accordance with the drawings. Make no substantial alterations without prior approval of the Owner and the Engineer.

3.7 CABLE TERMINATION AND TEST PLANS

- A. General
1. Provide proof of testing technician(s) certification for operation of the specific units of test equipment, which are proposed for use.
 2. The contractor shall obtain CM approval for each termination and test plan prior to execution of the work.
 3. This Section covers work necessary to furnish communications system testing, including the following:
 - a. Outside Plant (OSP) Cabling Infrastructure (Campus LAN/WAN extension)
 - b. Back-Bone Cabling Infrastructure
 - c. Horizontal Cabling Systems
 4. Inspection Requirements:
 - a. As part of any performance test, inspect cable, material, and equipment for physical damage, continuity, and proper connection.
 - b. Verify identification and labeling at required locations for visibility, condition, legibility, and accuracy.
 5. Test Report Requirements – Each test report shall include the following sections:
 - a. Scope of testing
 - b. List of equipment used in the test with a photocopy of the factory calibration certificate.
 6. List of technicians performing the tests identified in the scope of testing
 7. Summary of test results: Hardcopy and electronic copies of the summary forms are to be delivered at conclusion of the project before final payment will be made.
 8. Individual test data sheets: The individual test data sheets shall be developed and completed by the contractor. Formatted output from cable scanners is typically acceptable provided they contain all of the test parameters including graphs of the information required by this Section.
- B. Cable Termination Plans
1. Submit detailed termination plans for both fiber optic and twisted pair cables, which describe how each system component will be installed and terminated.
- C. Cable Test Plans
1. Submit detailed test plans for both fiber optic and twisted-pair cable channels which include at least the following information:
 - a. Describe the tests to be performed.
 - b. Explain when and how each system component will be tested.
 - c. List the test equipment to be used.
 - d. Itemize how theoretical loss budgets and test parameters will be calculated and listed.

- e. Provide an example of the test reporting documentation for each type of test, which provides a written verification of the results, as required in paragraph 2 below.
2. Provide testing documentation which includes:
 - a. Dates and times of test
 - b. Personnel performing tests
 - c. Initial test results
 - d. Description of discrepancies found or failure, if any
 - e. Corrective action, if any
 - f. Date and person performing corrections
 - g. Retest results, if required
 - h. Include space for Owner's sign-off
 - i. Copy of test equipment calibration certificates
 - j. Intrabuilding (Vertical and Horizontal Subsystem) fiber optic segment post-installation test plan
3. Twisted-Pair Cable Tests: Testing shall be performed using a minimum level IIIe tester, approved by the engineer.
4. Twisted-Pair Test Plans: Provide separate post-installation test schemes for the following activities:
 - a. Backbone Subsystem twisted-pair segment test plan.
 - b. Horizontal Subsystem twisted-pair segment test plan.
5. Fiber-Optic Cable Tests: Testing shall be performed using a level IIIe tester, with approved test-heads approved by the engineer.
6. Fiber-Optic Test Plans: Provide separate post-installation test schemes for the following activities:
 - a. Backbone subsystem fiber-optic segment test plan.
 - b. Horizontal subsystem fiber-optic segment test plan.

3.8 TESTING AND INSPECTION OF COMMUNICATIONS EQUIPMENT

- A. Provide tests specified below, when applicable, and as indicated under individual items of material, equipment, and work specified in this Specification.
 1. Furnish all test equipment and instruments required for the tests.
 2. Responsible, qualified employees of the contractor in the presence of the Owner or an authorized representative shall perform the cable testing.
 3. All individuals involved in the testing phase of the project shall not have been involved in the installation phase nor shall have immediate knowledge of the installation task.

3.9 FINAL TEST AND ADJUST

- A. The contractor shall be responsible for post-installation performance testing of all cabling systems specified elsewhere in this Section of the Contract Documents.
 1. Testing procedures shall permit recording the length of each link, theoretical loss budget, and tested parameters for each pair and fiber, including space for sign-off by CM and Owner.
 2. Any cable links or fiber strands, which fail to meet performance test criteria, shall be re-terminated, re-connectorized, or replaced by the contractor free of charge.

3. Submit final field test documentation in list form, including the CM signature for Owner's approval.
- B. Unshielded Twisted-Pair Cable System Testing
 1. Permanent Link Test Configuration: Perform metered tests on each multi-pair twisted-pair and/or four-pair UTP cable through the wiring block, patch panel, at each end of the cable section and/or telecommunication outlet (T.O.). The permanent link test shall be undertaken as described in ANSI/TIA 568.2-D.
 2. Performance Testing:
 - a. Horizontal Cable System:
 - 1) Use a minimum Level IIIe field test instrument capable of the following swept/stepped frequency voltage measurements in accordance with the performance parameters required by ANSI/TIA 568.2-D
 - 2) Test each horizontal link to verify/determine, wire map, length, attenuation, skew, and near-end-crosstalk (NEXT) as described in ANSI/TIA 568.2-D.
 - b. Test Reports: Include field test results for each cable including cable link length in accordance with ANSI/TIA 568.2-D.
 - c. The test summary shall include:
 - 1) Cable Identification as it appears on cable schedule.
 - 2) Cable identification as it appears on the individual test reports.
 - 3) Cable identification as it is labeled in accordance to the Specifications.
 - 4) Pass/Fail Status.
 - 5) All test parameters shall appear on each test document including graphics and indicating each test parameter result.
 - 6) The individual test data sheet shall include the automated print-out produced by the cable scanning equipment.

3.10 CONSTRUCTION REVIEW

- A. The Engineer and Owner will review and observe installation work to ensure compliance by the contractor with the requirements of the Contract Documents.
- B. The contractor shall inspect, and test completed communications installations to demonstrate specified performance levels including the following:
 1. Furnish all instruments and personnel required for the inspections and tests.
 2. Perform tests in the presence of the Engineer and Owner.
 3. Demonstrate that the system components operate in accordance with the Contract Documents.
- C. Review, observation, assistance, and actions by the Engineer and Owner shall not be construed as undertaking supervisory control of the work or of methods and means employed by the contractor. The Engineer and Owner review and observation activities shall not relieve the contractor from the responsibilities of these Contract Documents.
- D. The fact that the Engineer and Owner does not make early discovery of faulty or omitted work shall not bar the Owner from subsequently rejecting this work and withholding payment until the contractor makes the necessary corrections.
- E. Regardless of when discovery and rejection are made, and regardless of when the contractor is ordered to correct such work, the contractor shall have no claim against

the Engineer or Owner for an increase in the Subcontract price, or for any payment on account of increased cost, damage, or loss.

3.11 PROJECT RECORD DOCUMENTS

- A. Provide detailed project record documentation for sections listed in paragraph 1.03-C above, in addition to the standard requirements, within 30 days after completion of the work.
- B. Maintain separate sets of redlined record drawings for the communications work, which show the exact placement, and identification of as-built system components. These are subject to weekly review by the CM, Owner, or its representative.
- C. Provide communication room record drawings which indicate exact placement for all components; e.g., conduit, wireway, cable tray, backboards, equipment cabinets, equipment racks, and cross-connect equipment, etc.
- D. Provide communication wiring and cabling record drawings and schedules which indicate exact placement, routing, and connection details for all components, e.g., twisted-pair cables, splices, cable cross-connect termination locations, enclosures, telecommunications outlets, and cross-connect jumpers, patch cords, etc.
- E. Provide network schematics when appropriate.
- F. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- G. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for TR/IDFs, backbone pathways and cables, entrance pathways and cables.

3.12 CONTRACTOR REQUIREMENTS

- A. General
 - 1. Contractor shall be a current registered installer of the manufacturer cabling and connectivity solution being installed. A copy of the corporate manufacturer certification shall be included with the product submittal package.
 - 2. Contractor shall have at least 5 years documented experience installing and testing structured cabling systems of similar type and size.
 - 3. Contractor shall employ at least one BICSI Registered Communication Distribution Designer (RCDD) to sign-off on all designs offered, including stamping the design with their current BICSI/RCDD stamp.
 - 4. Contractor shall have all necessary permits, licenses, and inspections required for the performance of data, voice, and fiber optic cable installations.
 - 5. At least 30 percent of the technicians installing low-voltage copper and fiber systems on the job shall have a current installation certificate by the manufacturer cabling and connectivity solution being installed.
 - 6. The Contractor shall provide a Project Manager to serve as the single point of contact to manage the installation, speak for the contractor and provide the following functions:
 - a. Initiate and coordinate tasks with the Owner's Project Manager and others as specified by the project schedule.

- b. Provide day-to-day direction and-site supervision of Contractor personnel.
 - c. Ensure conformance with all contract and warranty provisions.
 - d. Acknowledge and remediate findings of the Owner's weekly site project meetings.
 - e. This individual will remain Project Manager for the duration of the project. The contractor may change Project Manager only with the written approval of the Owner.
 - 7. Contractor Project Manager on site shall have completed Deployment training and hold certificates for both copper and fiber.
- B. Other Contractor Responsibilities
 - 1. Confirmation of Pathway and Cable Manager sizing:
 - a. Wherever cabling pathways or managers are installed, it is the Contractor's responsibility to confirm pathway or manager sizing to represent no more than 25% fill upon installation according to manufacturer's fill tables.
 - b. Pathways deemed overfilled upon installation will not be accepted and shall be remedied at Contractor expense.
 - 2. Contractor is responsible for the removal and disposal of all installation and construction debris created in the process of the job.
 - 3. All work areas will be cleaned at the conclusion of the daily work period and no tools or materials shall be left in a manner as to pose a safety hazard.
 - 4. Projects are not considered finished and will not be paid by the Owner until all debris, dust, etc. has been cleaned and removed to the satisfaction of the Owner.
 - 5. Contractor shall remove all abandoned cable per Article 800 of the National Electrical Code and per TIA and BICSI standards, recycling these materials where possible. Removal of orphaned cable is mandatory. Contractors shall consider this when placing bids.
 - 6. Contractor shall abide by all Owner Security Policies pertaining to access and conduct while on the Owner's property.
 - 7. Contractor shall obey all posted speed limits and parking regulations at the Owner's facilities where the work is being performed.
 - 8. Contractor understands that illegally parked vehicles will be towed, and Contractor is responsible for and will assume all costs associated with towing.

3.13 DEFINITION OF ACCEPTANCE

- A. System acceptance shall be defined as that point in time when the following requirements have been fulfilled:
- B. All submittals and documentation have been submitted, reviewed, and approved.
 - 1. The complete system has successfully completed all testing requirements.
- C. All punch list items have been corrected and accepted.

3.14 TERMINATION OF SERVICES

- A. The Owner reserves the right to terminate the Contractor's services if at any time it is determined the Communication Contractor is not fulfilling their responsibilities as defined within this document and all associated project documentation.
- B. Upon termination, the Communications Contractor shall be restricted from the premises and compensated for the percentage of work completed satisfactorily.

June 15, 2026

**Smithsonian Project Code 2533105
SmithGroup Project No. 00100084**

- C. Contractor's appearance and work ethic shall be of a professional manner. Dress shall be appropriate to the work being performed.
- D. Conduct on the Owner's property will be professional in nature.
- E. Any person in the Contractor's employ working on an Owner's project considered by the Owner to be incompetent, disorderly, or for any other reason unsatisfactory or undesirable to IT, such person shall be removed from the Owner's project.

END OF SECTION

FOR REFERENCE ONLY

SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Provide all materials and labor for the installation of a grounding and bonding system for communications infrastructure. This section includes requirements for providing a permanent grounding and bonding infrastructure for communications circuits, raceways, and cable tray.

1.2 DEFINITIONS

- A. "PBB" shall mean Primary Bonding Busbar. There is typically one PBB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground. In previous standards, this was known as the TMGB (Telecommunications Main Grounding Busbar)
- B. "SBB" shall mean Secondary Bonding Busbar. There is typically one SBB per telecommunications room. The SBB is connected both to the PBB and to building structural steel or other permanent metallic systems. In previous standards, this was known as the TGB (Telecommunications Grounding Busbar)
- C. "TBB" shall mean Telecommunications Bonding Backbone. The TBB is a conductor used to connect the PBB to SBBs.
- D. "TBC" Telecommunication Bonding Conductor
- E. "BBC" Backbone Bonding Conductor
- F. For additional definitions, refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete, permanent Grounding and Bonding infrastructure for communications circuits, raceways, and cable trays as hereinafter specified and/or shown on the Contract Documents. The Grounding and Bonding system shall support an ANSI/TIA and ISO/IEC compliant communications Structured Cabling System (SCS).

- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working ANSI/TIA and ISO/IEC compliant Grounding and Bonding system.

1.5 SUBMITTALS

- A. Refer to Section 27 00 00 – Communications General

1.6 QUALITY ASSURANCE

- A. Contractor Warranty:
 - 1. Provide a Contractor-endorsed two-year service warranty against defects in materials and workmanship.
 - a. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
 - b. The Contractor Warranty period shall commence upon Owner acceptance of the work.
- B. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed.
- C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing data cabling.

PART 2 PRODUCTS

2.1 GENERAL

- A. Materials shall consist of busbars, supports, bonding conductors and other incidentals and accessories as required.

2.2 MATERIALS

- A. Grounding/Bonding:
 - 1. Primary Bonding Busbar (PBB):
 - a. Large (20" x 4" x 1/4"), Pre-drilled: CPI 40153-020, or equal
 - 2. Rack Bonding Busbar (RBB)
 - a. Horizontal 19" wide rack: CPI 10610-019, or equal
 - 3. Compression Lugs
 - a. Compression lugs, two-hole, slotted (sized accordingly): CPI 40162-XXX, or equal
 - 4. Equipment Bonding Jumper
 - a. Bonding Jumper Kit: CPI 40159-010, or equal
 - 5. Cable Runway Bonding Strap
 - a. Bonding strap kit: CPI 40164-001
 - 6. C-Type Compression Taps
 - a. Compression Taps (sized accordingly): CPI 40163-XXX, or equal

7. Telecommunications Bonding Backbone:
- a. Green insulated copper conductor, minimum size of No. 6 AWG. The TBB shall be sized at 2 kcmil per linear foot of conductor length up to a maximum size of 3/0 AWG. Insulation shall meet fire ratings of its pathway.

Sizing of the TBB	
TBB Length (ft)	TBB Size (AWG)
Less than 13	6
14-20	4
21-26	3
27-33	2
34-41	1
42-52	1/0
53-66	2/0
67-84	3/0
85-105	4/0
106-125	250 kcmil
126-150	300 kcmil
151-175	350 kcmil
176-250	500 kcmil
251-300	600 kcmil
301 or greater	750 kcmil

8. Grounding Conductor: #6 AWG insulated (green in color) copper conductor.
- B. Firestopping material:
1. Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.

PART 3 EXECUTION

3.1 GENERAL

- A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
- B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NEC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.
- C. All work shall comply with the standards, references and codes listed in PART 1 -- REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.

- D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
- E. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
- F. Install the grounding and bonding system in a manner ensuring that communications circuits, when installed, are able to fully comply with the ANSI/TIA and other references listed in Part 1 — References, above.
- G. Remove surplus material and debris from the job site and dispose of legally.

3.2 INSTALLATION

- A. The grounding and bonding infrastructure system shall not make use of the building plumbing system, unless required to do so by the NEC.
 - 1. Coordinate the installation of the grounding and bonding system with the electrical power distribution system grounding infrastructure.
- B. Ground/Bonding:
 - 1. PBB: Provide a minimum of one PBB per telecommunications entrance room for each building and as shown on the Contract Documents. Install PBB(s) and directly bond PBB(s) to electrical service ground and to associated TBB(s). Group protector, busbar bonding, and approved building grounding conductors toward one end of the PBB and leave space for equipment grounding conductors on the other end.
 - 2. TBB(s) and Grounding Conductors: Provide TBB(s) and grounding conductors as shown on the Contract Documents and as required to bond all non-current carrying metal telecommunications equipment and materials to the nearest SBB. Use TBB(s) to connect the PBB to each SBB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. Insulate TBB(s) and conductors from their support. TBB(s) and grounding conductors shall be continuous (without splices).
 - a. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
- C. Firestopping
 - 1. Only employees trained/certified by the firestopping manufacturer shall apply firestopping materials.
 - 2. Maintain the fire rating of all penetrated fire barriers. Fire stop and seal all penetrations made during construction.
 - a. Provide firestopping material for through and membrane penetrations of fire-rated barriers.
 - b. Install firestops in strict accordance with manufacturer's detailed installation procedures.
 - c. Install firestops in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and applicable codes and standards referenced in PART 1 – REFERENCES. Apply of sealing material in a manner acceptable to the local fire and building authorities.

June 15, 2026

**Smithsonian Project Code 2533105
SmithGroup Project No. 00100084**

- d. For demolition work, apply firestopping to open penetrations in fire rated barriers where cable is removed. Apply firestopping regardless of whether or not the penetrations are used for new cable or left empty after construction is complete.
- e. Firestopping material used to seal open penetrations through which cable passes shall be re-usable/re-enterable.

3.3 LABELING AND ADMINISTRATION

- A. Refer to Section 27 05 53 - Identification for Communications Systems for all Labeling materials and procedures.

END OF SECTION - 27 05 26

FOR REFERENCE ONLY

SECTION 27 0528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. Provide all materials and labor for the installation of a pathway system for inside plant communications circuits. This section includes requirements for horizontal and building backbone raceways, fittings, and boxes specific to communications circuits (cabling) for voice and data.

1.2 DEFINITIONS

- A. "EMT" shall mean Electrical Metallic Tubing.
- B. "RMC" shall mean Rigid Metal Conduit.
- C. "SMR" shall mean Surface Metal Raceway.
- D. "Raceway" shall mean any enclosed channel for routing wire, cable, or busbars.
- E. "PBB" shall mean Primary Bonding Busbar. There is typically one PBB per building, located in the main telecommunications room. This busbar is directly bonded to the electrical service ground. In previous standards, this was known as the TMGB (Telecommunications Main Grounding Busbar)
- F. "TBB" shall mean Telecommunications Bonding Backbone. The TBB is a conductor used to connect the PBB to SBBs.
- G. "Pull box" shall mean a metallic box with a removable cover, used to facilitate pulling cable through conduit runs longer than 100' or in which there are more than 180 degrees of bends.
- H. "Junction box" shall mean a pull box wherein a feeder conduit transitions to multiple distribution conduits.
- I. For additional Definitions refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SYSTEM DESCRIPTION

- A. Furnish, install, and place into satisfactory and successful operation all materials, devices, and necessary appurtenances to provide a complete Raceway system as hereinafter specified and/or shown on the Contract Documents. The Raceway system

shall support an ANSI/TIA and ISO/IEC compliant communications Structured Cabling System (SCS).

- B. The work shall include materials, equipment and apparatus not specifically mentioned herein or noted on the Contract Documents, but which are necessary to make a complete working Raceway system.

1.5 SUBMITTALS

- A. Make submittals in accordance with:
 - 1. Section 00 00 00 - Procurement and Contracting Requirements
 - 2. Section 01 33 00 - Submittal Procedures.
 - 3. Section 27 05 00 - Common Work Results for Communications

1.6 QUALITY ASSURANCE

- A. Contractor Warranty:
 - 1. Provide a Contractor-endorsed one-year service warranty against defects in materials and workmanship.
 - a. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
 - b. The Contractor Warranty period shall commence upon Owner acceptance of the work.
- B. Listing and Labeling: Provide raceways and boxes specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in NEC, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- C. Comply with NECA's "Standard of Installation."
- D. Comply with NEC.

PART 2 PRODUCTS

2.1 GENERAL

- A. Materials shall consist of conduit, surface metal raceway, outlet boxes, fittings, enclosures, pull boxes, and other raceway incidentals and accessories as required for inside plant communications circuits.

2.2 MATERIALS

- A. Pathways and Cable Supports
 - 1. Installation and materials for the raceway and boxes for the SCS shall be as specified under Division 16 Section — "Raceways and Boxes for Communications Circuits" except where noted below.
 - 2. Innerduct: 1 ¼" Outside Diameter, bright orange in color.
 - 3. Pull Strings: Plastic or nylon with a minimum test rating of 200 lb.
 - 4. Conduit:
 - a. EMT. 1" minimum conduit size. Flexible metal conduit (FMC) is not acceptable.

- 1) Conduit: Galvanized steel tubing meeting ANSI C80.3.
- 2) Couplings: Steel, cast iron, or malleable iron compression type employing a split, corrugated ring and tightening nut, with integral bushings and locknuts. Indent-type and setscrew-type couplings are not permitted.
- b. RMC. 1" minimum conduit size.
 - 1) Conduit: Hot dipped galvanized steel with threaded ends meeting ANSI C80.1.
 - 2) Couplings: Unsplit, NPT threaded steel cylinders with galvanizing equal to the conduit.
 - 3) Nipples: Same as conduit, factory-made up to 8 inches in diameter, no running threads.
5. Sleeves: EMT conduit, with insulated throat bushings for each end
6. Outlet boxes: Minimum 4"x4" size, 2 1/8" minimum depth, with extension rings (if needed) and single gang covers (i.e., mud rings), unless otherwise noted on the Contract Documents. Combined interior depth of outlet box, extension ring and cover shall be a minimum 2-1/2". Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for 1" trade size conduit or connector entrance, meeting NEMA OS 1.
7. Junction Boxes and Pull Boxes: Stamped steel, deep drawn one piece (without welds or tab connections), galvanized, with knockouts for conduit or connector entrance. Boxes 6"x6"x4" or larger may be code gauge fabricated steel continuously welded at seams and painted after fabrication.
 - a. Dry locations: meeting NEMA OS 1.
 - b. Wet locations: NEMA OS 3R.
8. Miscellaneous Fittings:
 - a. Locknuts and conduit bushings: Malleable iron
 - 1) Appleton, Crouse Hinds, OZ Gedney, or equal
 - b. Through wall seals and floor seals shall be:
 - 1) OZ Gedney FS and WS series, or equal.
- B. Firestopping
 1. Firestopping material: Conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions. Acceptable manufactures include:

PART 3 EXECUTION

3.1 GENERAL

- A. Coordination
 1. Coordinate layout and installation of raceways and boxes with other construction elements to ensure adequate headroom, working clearance, and access.
- B. Examine surfaces and spaces to receive raceways, boxes, enclosures, and cabinets for compliance with installation tolerances and other conditions affecting performance of

raceway installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

- C. All wall and floor penetrations shall be sealed to maintain fire and/or STC ratings.

3.2 INSTALLATION

- A. Install raceways, boxes, enclosures, and cabinets as indicated, according to manufacturer's written instructions. Provide a raceway for each location indicated. Do not gang raceway into wireways, pull boxes, junction boxes, etc., without specific approval from the Designer.
- B. Conduit:
1. Install EMT unless other conduit is shown on the Contract Documents or is required by Code.
 2. Install conduit as a complete, continuous system without wires, mechanically secured and electrically connected to metal boxes, fittings and equipment. Blank-off unused openings using factory-made knockout seals.
 3. Run conduit in the most direct route possible, parallel to building lines. Do not route conduit through areas in which flammable material may be stored.
 4. Keep conduit at least 6 inches away from parallel runs of flues and steam or hot-water pipes or other heat sources operating at temperatures above one-hundred degrees Fahrenheit. Install horizontal conduit runs above water piping.
 5. Keep conduit away from sources of electromagnetic interference as follows:
 - a. 5 inches from fluorescent lighting
 - b. 12 inches from conduit and cables used for electrical power distribution
 - c. 48 inches from motors or transformers
 6. Do not exceed 90 meters total length for a given conduit run to be used for distribution cabling (from outlet box to telecommunications room), including intermediate conduits and junction boxes.
 7. Install conduit exposed, except in finished areas or unless shown otherwise on the drawings. Do not install conduit below grade/slab unless specifically shown on the Contract Documents as being installed below grade/slab.
 8. Install exposed conduit in lines parallel or perpendicular to building lines or structural members except where the structure is not level. Follow the surface contours as much as practical. Do not install crossovers or offsets that can be avoided by installing the conduit in a different sequence or a uniform line.
 - a. Run parallel or banked conduits together, on common supports where practical.
 - b. Make bends in parallel or banked runs from same centerline to make bends parallel.
 9. Conduits concealed above ceilings, furred spaces, etc., which are normally inaccessible may be run at angles not parallel to the building lines.
 10. Wherever practical, route conduit with adjacent ductwork or piping and support on common racks. Base required strength of racks, hangers, and anchors on combined weights of conduit and piping.
 11. Where conduits cross building expansion joints, use suitable sliding or offsetting expansion fittings. Unless specifically approved for bonding, use a suitable bonding jumper.
 12. Support conduits as specified in Section 16050 "Basic Electrical Materials and Methods."

- a. Provide anchors, hangers, supports, clamps, etc. to support the conduits from the structures in or on which they are installed. Do not space supports farther apart than five feet.
 - b. Provide sufficient clearance to allow conduit to be added to racks, hangers, etc. in the future.
 - c. Support conduit within three feet of each outlet box, junction box, gutter, panel, fitting, etc.
13. Ream conduits to eliminate sharp edges and terminate with metallic insulated grounded throat bushings. Seal each conduit after installation (until cable is installed) with a removable mechanical-type seal to keep conduits clean, dry and prevent foreign matter from entering conduits.
 14. Install a pull string in each conduit.
 15. For conduits entering through the floor of a telecommunications room, terminate conduits 6" above the finished floor.
 16. Do not install communications conduits in wet, hazardous or corrosive locations.
 17. Where conduit is shown embedded in masonry, embed conduit in the hollow core of the masonry. Horizontal runs in the joint between masonry units are not permitted.
 18. Where conduit is shown embedded in concrete, embed conduit a minimum of two inches from the exterior of the concrete. Do not place conduit in concrete less than 4 inches thick.
 - a. A minimum one-inch trade size conduit shall be used. Conduits sized smaller than one-inch trade size conduit are not permitted embedded in concrete without approval from client.
 - b. Run conduit parallel to main reinforcement.
 - c. Conduit crossovers in concrete are not permitted.
 19. Where conduit exits from grade or concrete, provide a rigid steel elbow and adapter.
 20. Where conduit enters a space through the floor and terminates in that space, terminate the conduit at 6" above the finished floor.
 21. Where conduits terminate at a cable tray, the conduits shall be consistently terminated no more than 8" from the cable tray and have a visually uniform appearance.
 22. Where several circuits follow a common route, stagger pull boxes or fittings.
 23. Where several circuits are shown grouped in one box, individually fireproof each conduit.
 24. Bend and offset metal conduit with standard factory sweeps or conduit fittings. Keep legs of bends in the same plane and straight legs of offsets parallel, unless otherwise indicated.
 - a. Conduit sweeps:
 - 1) Sweeps shall not exceed 90 degrees.
 - 2) Do not exceed 180 degrees for the sum total of conduit sweeps for a section of conduit (between conduit termination points).
 - 3) Sweep radius shall be at least 10 times the internal diameter of the conduit.
 - 4) 90-degree condulets (LB's) and electrical elbows are not acceptable.

- b. Factory-manufactured sweeps are required for bends in conduit larger than 1- $\frac{1}{4}$ " trade size.
- c. For bends in 1 $\frac{1}{4}$ " trade size conduit and larger, field-manufactured bends (using a hydraulic bender with a 1 $\frac{1}{4}$ " boot) are permitted only when factory-manufactured sweeps are not suitable for the conditions. In all other cases, factory-manufactured sweeps are required. "Hickey-bender" use is prohibited.
- 25. Connect conduit to hubless enclosures, cabinets, and boxes with double locknuts and with insulating type bushings. Use grounding type bushings where connecting to concentric or eccentric knockouts. Make conduit connections to enclosures at the nearest practicable point of entry to the enclosure area where the devices are located to which the circuits contained in the conduit will connect.
- 26. Penetrations for raceways:
 - a. Do not bore holes in floor and ceiling joists outside center third of member depth or within two feet of bearing points. Holes shall be 1- $\frac{1}{4}$ " diameter maximum.
 - b. Penetrate finished walls and finished surfaces with a PVC or sheet metal sleeve with an interior diameter (ID) at least 1/4" greater than the outer diameter (OD) of the conduit, set flush with walls, pack with fiberglass, seal with silicone sealant.
 - c. Penetrate poured-in-place walls and free slabs with a cast iron sleeve (or Schedule 40 PVC black pipe sleeve for above-grade only) with retaining ring or washer. Set sleeves flush with forms or edges of slab. Pack around conduit with fiberglass and seal with silicone sealant.
- 27. Raceway terminations and connections:
 - a. Join conduits with fittings designed and approved for the purpose and make joints tight. Do not use set indent-type or screw-type couplings.
 - b. Make threaded connections waterproof and rustproof by applying a watertight, conductive thread compound. Clean threads of cutting oil before applying thread compound.
 - c. Make conduit terminations tight. Use bonding bushings or wedges at connections subject to vibration. Use bonding jumpers where joints cannot be made tight.
 - d. Cut ends of conduit square using a hand saw, power saw or pipe cutter. Ream cut ends to remove burrs and sharp ends. Where conduit threads are cut in the field, cut threads to have same effective length, same thread dimensions and same taper as specified for factory-cut threads.
 - e. Provide double locknuts and insulating bushings at conduit connections to boxes and cabinets. Align raceways to enter squarely and install locknuts with dished part against the box. Use grounding type bushings where connecting to concentric or eccentric knockouts.
 - f. Where conduits are terminated with threaded hubs, screw raceways or fittings tightly into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align raceways so the coupling is square to the box and tighten the chase nipple, so no threads are exposed.
- 28. Install conduit sealing fittings according to manufacturer's written instructions. Locate fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed conduits, install each fitting in a flush

steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

- a. Where conduits pass from warm to cold locations, such as the boundaries of air conditioned or refrigerated spaces and where conduits enter or exit buildings from outdoor areas, including underground ducts or conduit runs.
 - b. Where otherwise required by the NEC.
29. Conduit shall be clean and dry.

C. Sleeves:

1. Provide sleeves where required, sized as noted on the Contract Documents. Where not noted, sleeve sizing shall be determined by the type and quantity of cable to be routed through the sleeve per TIA 569A cable capacity standards, plus an additional 20% for future expansion.
2. Provide roto-hammering or core drilling where required for installation.
3. Seal between sleeve and wall or floor in which the sleeve is installed. Firestop all penetrations to restore wall or floor to pre-penetration fire-rating and/or STC rating.

D. Outlet Boxes:

1. Provide outlet boxes and covers as shown on the Contract Documents and as needed. Verify that the appropriate cover type and depth is provided for each type of wall and finish. Provide extension rings as needed.
2. Coordinate box locations with building surfaces and finishes to avoid bridging wainscots, joints, finish changes, etc.
3. Install boxes in dry locations (not wet, corrosive, or hazardous).
4. Attach boxes securely to building structure with a minimum of two fasteners. Provide attachments to withstand a force of one hundred pounds minimum, applied vertically or horizontally.
5. Install boxes at the following heights to the bottom of the box, except where noted otherwise:
 - a. Wall mounted telephones: 48" above finished floor, attached to wall studs.
 - b. Workstation outlets: 18" above finished floor.
 - c. Place boxes for outlets on cabinets, countertops, shelves, and similar boxes located above countertops two inches above the finished surface or two inches above the back splash. Coordinate and verify size, style, and location with the supplier or installer of these items prior to outlet box installation.
6. Recessed mounted outlet boxes:
 - a. Recess boxes in the wall, floor, and ceiling surfaces in finished areas. Set boxes plumb, level, square and flush with finished building surfaces within one-sixteenth inch for each condition. Set boxes so that box openings in building surfaces are within one-eighth inch of edge of material cut-out and fill tight to box with building materials. Single gang opening shall extend at least to the finished wall surface and extend not more than 1/8 inch beyond the finished wall surface. Provide backing for boxes using structural material to prevent rotation on studs or joists.
 - b. Install floor boxes level and adjust to finished floor surface.
7. Surface-mounted outlet boxes:
 - a. For boxes surface-mounted on finished walls, provide Wiremold outlet box or equivalent. Cut box as necessary to accept conduit.

- b. For boxes surface-mounted on unfinished walls (i.e., electrical rooms, mechanical rooms), provide 4"x4" (minimum) outlet box with single gang cover.

E. Junction Boxes:

1. Provide junction boxes as shown on the Contract Documents and as required.
- a. Where sizing is not shown on the Contract Documents, size junction box length and depth according to the size of the feeder conduit in the following table:

Feeder Conduit Size	Box Length	Box Depth
1"	12"	4"
1-1/4"	12"	4"
1-1/2"	12"	4"
2"	24"	4"
2-1/2"	24"	6"
3"	36"	6"
3-1/2"	48"	6"
4"	60"	6"

- b. Where sizing is not shown on the Contract Documents, size junction box width according to the following formula:

- 1) From the table below, select the width associated with the largest conduit on the distribution side of the box. For each additional distribution conduit, add the "Increase Width" value associated with the size of that distribution conduit to the box width for the largest distribution conduit.
 - (a) For example, if the distribution side of the junction box has one 1-1/4" distribution conduit and three 1" distribution conduits, the total distribution-side width would be 6" + 2" + 2" + 2" = 12".
- 2) Repeat the above process for the feeder side of the junction box. Junction boxes are typically fed by a single conduit, therefore unless the box has more than one feeder conduit, the "Increase Width" part of the formula is unnecessary.
 - (a) For example, if the feeder side of the junction box has two 2" feeder conduits the total feeder-side width would be 8" + 5" = 13".
- 3) The larger of the two width calculations (distribution side vs. feeder side) shall be the width of the junction box to be provided.
 - (a) For example, if the distribution-side width were 10" and the feeder-side width were 13", provide a 13" wide junction box.

F. Pull Boxes:

1. Provide pull boxes as shown on the Contract Documents and as required.
- a. Where sizing is not shown on the Contract Documents, size pull boxes as follows:

Size of Largest Conduit	Box Width	Box Length	Box Depth
1"	4"	12"	4"
1-1/4"	6"	12"	4"
1-1/2"	8"	12"	4"
2"	8"	24"	4"
2-1/2"	10"	24"	6"
3"	12"	36"	6"
3-1/2"	12"	48"	6"
4"	15"	60"	6"

- b. Where a pull box is required with conduits 1" trade size or smaller, an outlet box may be used as a pull box. Where outlet boxes are used as pull boxes, the outlet boxes shall be dedicated for use as a pull box and shall not host cable termination hardware.
 2. A pull box may not be substituted for a 90-degree bend. 90-degree condulets (LB's) are not acceptable.
 3. Install pull boxes in an accessible location, readily accessible both at time of construction and after building occupation. Do not install pull boxes in inaccessible interstitial building space.
 4. Where pull boxes are to be mounted on ceiling structure above ceiling grid, do not mount higher than 4' above grid (mount on wall instead).
 5. Install hinged-cover enclosures and cabinets plumb and supported at each corner.
 6. Install pull boxes so that the access door opens from the side where the cable installer will normally work (typically from the bottom, or floor side, of the box).
 - a. Where a pull box is installed in a ceiling space, provide full access to the junction box door and adequate working room for both the installation personnel and for proper looping of cable during installation.
 - b. Provide a securable access cover (or pull box door if pull box is exposed) in hard lid ceilings.
 7. Install pull boxes such that conduits enter and exit at opposite ends of the box as follows:
- G. Ladder Rack:
1. Install ladder rack per manufacturer's instructions with flat (rung) side up. Provide ladder rack to affix tops of racks to walls, to route cable from walls to racks within telecommunications rooms, and in locations shown in the Contract Documents. Size and installation as shown in the Contract Documents. Cut ends of ladder rack square. Ream cut the ends to remove burrs and sharp edges. Cap cut ends with manufacturer's recommended caps. Mount retaining posts as required. Provide Cable Radius Drops wherever cable is to drop from one section of ladder rack to another lower section of ladder rack or onto racks or cabinets. Provide 90-degree horizontal radius bends for each 90-degree change in direction of ladder rack angle. Provide Cable Retaining Posts for all sides of ladder rack within a telecommunications room not directly adjacent to a wall. Affix posts at 2-foot centers and at corners and/or junctions. Provide Cable Runway Grounding kits

- across ladder rack splices and where ladder racks end at or are connected to racks/cabinets.
2. Sleeves shall be installed at all instances where a ladder rack passes through a partition. Sleeves shall be sized to match the capacity of the ladder rack and shall be sealed to match the fire and/or STC rating of the partition.
- H. Surface Raceway:
1. Provide for all surface mounted stations as shown in the Contract Documents.
 2. Provide surface raceway for all surface mounted telecommunications outlet boxes and as shown on the Contract Documents.
 3. Size surface raceway according to the quantity of cable to be routed through it according to ANSI/TIA 569 cable capacity standards, plus an additional 100% for future expansion. Size fittings/bends to accommodate Category 6A and fiber optic bend radii as specified in ANSI/TIA 569.
 4. Surface raceway shall be routed parallel to and perpendicular to surfaces or exposed structural members and follow surface contours.
 5. Mechanically and electrically continuous surface raceway shall be bonded and grounded to the Telecommunications Grounding system.
 6. Match surface raceway finish as close as possible to the finish of the wall it is to be mounted on but do not paint surface raceway. Surface raceway shall be:
 - a. Installed per Article 352 of the NEC. Surface raceway shall be installed as mechanically and electrically continuous and bonded in accordance with NEC and ANSI/TIA 607-C codes and standards.
 - b. Installed according to ANSI/TIA standards for fiber optic and Category 6A bend radii. Bend points shall have a minimum two-inch radius control.
 - c. Securely supported using screws or other anchor-type devices (tape or glue is not an acceptable support medium) at intervals not exceeding 5 feet and with no less than two supports per straight raceway section. Surface raceway shall be supported in accordance with the manufacturer's installation requirements.
 - d. Completely installed including insulating bushings and inserts where required by manufacturer's installation requirements.
 - e. Installed parallel and perpendicular to surfaces or exposed structural members and following surface contours where possible.
 - f. Close any unused raceway openings.
- I. Backboards: Provide backboards as shown on Contract Documents. Backboards shall be capable of supporting attached equipment and painted with a minimum of two coats (over primer) of fire retardant, non-conductive paint, and one coat of white colored semi-gloss topcoat paint. Mount A-C plywood backboards with the "A" side exposed.
- J. Sleeves: Provide sleeves where required for cable pass-thru through building structures and/or fire rated barriers. Provide roto-hammering or core drilling where required for sleeve installation. Seal (and if a fire rated barrier, firestop) between sleeve and building structure and/or barrier. Size sleeves:
1. As noted in the Contract Documents.
 2. Where not noted, size sleeves a minimum of 2 inches in diameter or by the type and quantity of cable to be routed through the sleeve per ANSI/TIA 569 cable capacity standards plus an additional 100% for future expansion - whichever is greater.

- K. D-Rings: Provide D-Rings as necessary to route exposed cables in telecommunications rooms and on backboards and for raceway for routing cable in non-exposed open access environments, and as shown in the Contract Documents. D-Rings may be affixed to wall/ceiling structures or other supports, but not attached to a ceiling support system. In telecommunications rooms, mount D-Rings at 12-inch intervals and as shown in the Contract Documents. Mount D-rings used for raceway in open access environments at 4-foot intervals unless otherwise specified in the Contract Documents.
 - 1. Size D-Rings as noted in the Contract Documents.
 - 2. Where not noted, size D-Rings according to the type and quantity of cable to be routed through the ring per TIA 569 cable capacity standards, plus an additional 100% for future expansion, but not less than a minimum of 2 inches in diameter.
- L. Ladder Cable Tray: Install cable tray where indicated, in accordance with manufacturer's instructions. Provide sufficient space encompassing cable tray to permit access for installing and maintaining cables. Support cable raceways every 4 feet minimum and at 6 inches from ends. Route pathways a minimum of 6 inches of clearance from fluorescent light fixtures. In areas without suspended ceilings, install cable tray raceways 12 inches below the lowest obstruction unless otherwise directed.
- M. Innerduct: Provide bright orange innerduct as pathway for backbone fiber optic cables (backbone only – not station cables), from backbone fiber patch panels to conduit or plenum entrances, and as shown in the Contract Documents. Innerduct installed in plenum rated environments shall be plenum rated.
- N. Pull Strings: Provide a pull string in existing conduits that are to remain vacant after existing cable is demolished and in existing and new conduits that have new cable installed under this project.

3.3 LABELING AND ADMINISTRATION

- A. Refer to Section 27 05 53 - Identification for Communications Systems for all Labeling materials and procedures.

END OF SECTION - 27 05 28

SECTION 27 0528.10 - PATHWAYS FOR SECURITY SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 28 0500.10 Common Work Results for Electronic Security.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Nonmetallic conduits and fittings.
 - 3. Optical-fiber-cable pathways and fittings.
 - 4. Metal wireways and auxiliary gutters.
 - 5. Nonmetallic wireways and auxiliary gutters.
 - 6. Metallic surface pathways.
 - 7. Nonmetallic surface pathways.
 - 8. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. BICSI: Building Industry Consulting Service International
- C. GRC: Galvanized rigid conduit.
- D. IMC: Intermediate metal conduit.
- E. RTRC: Reinforced thermosetting resin conduit.
- F. TIA: Telecommunications Industry Association

1.4 ACTION SUBMITTALS

- A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Tele-power poles.
4. Boxes, enclosures, and cabinets.
5. Underground handholes and boxes.

- B. Shop Drawings: For custom enclosures and cabinets and custom underground handholes and boxes. Include plans, elevations, sections, and attachment details.

1.5 INFORMATION SUBMITTALS

- A. Seismic Qualification Data: Provide seismic bracing for all pathway racks, enclosures, cabinets, equipment racks, and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
 4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. General Requirements for Metal Conduits and Fittings:
1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 2. Comply with TIA-569-D.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. PVC-Coated Steel Conduit: PVC-coated GRC or IMC.
1. Comply with NEMA RN 1.

2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: compression.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
 5. Bushings: Required for all terminating conduit ends.
- I. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUITS AND FITTINGS

- A. Description: Nonmetallic raceway of circular section with manufacturer-fabricated fittings.
- B. General Requirements for Nonmetallic Conduits and Fittings:
 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 2. Comply with TIA-569-D.
- C. RNC: Type EPC-40-PVC or Type EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651A.
- F. RTRC: Comply with UL 2515A and NEMA TC 14.
- G. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.
- H. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 OPTICAL FIBER CABLE RIGID PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for riser installation unless otherwise indicated.
- B. Conduit Innerduct:
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.4 OPTICAL FIBER CABLE FABRIC PATHWAYS AND FITTINGS

- A. Description: [3 mm] [2"] [3"] [4"] single or multi cell polyester/nylon textile innerduct containing 1250 lb polyester flat woven pull tape, approved for [plenum] [riser] [general-use] [or] [outdoor/detectable] installation unless otherwise indicated.
- B. Manufacturer: MaxCell Group.
- C. Fittings: Compression-type conduit plugs with locking nuts and inflation-type termination bags.

2.5 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Sheet metal trough of rectangular cross section fabricated to required size and shape, without holes or knockouts, and with hinged or removable covers.
- B. General Requirements for Metal Wireways and Auxiliary Gutters:
 - 1. Comply with UL 870 and NEMA 250, Type 1, Type 3R, Type 4, Type 12, unless otherwise indicated, and sized according to NFPA 70.
 - 2. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 - 3. Comply with TIA-569-D.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.6 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Description: Fiberglass polyester extruded and fabricated to required size and shape, without holes or knockouts. Cover shall be gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections shall be flanged and have stainless-steel screws and oil-resistant gaskets.
- B. Description: PVC, extruded and fabricated to required size and shape, and having snap-on cover, mechanically coupled connections, and plastic fasteners.
- C. General Requirements for Nonmetallic Wireways and Auxiliary Gutters:
 - 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- D. Fittings and Accessories: Couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings shall match and mate with wireways as required for complete system.
- E. Solvents and Adhesives: As recommended by conduit manufacturer.

2.7 SURFACE METAL PATHWAYS

- A. Description: Galvanized steel with snap-on covers, complying with UL 5.
- B. Finish: Manufacturer's standard enamel finish in color selected by Architect. Prime coated, ready for field painting.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.8 SURFACE NONMETALLIC PATHWAYS

- A. Description: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC.
- B. Finish: Texture and color selected by Architect.
- C. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
- D. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

- E. Comply with TIA-569-D.

2.9 HOOKS (TELECOMMUNICATIONS USE ONLY)

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-D.
- D. ANSI/TIA Category 6, 6a, 7 compliant (3" bend radius).
- E. Galvanized steel.
- F. [J] [U] shape.

2.10 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-D.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep) and 4 inches by 2-1/8 inches by 2-1/8 inches deep (100 mm by 60 mm by 60 mm deep).
 - 5. Gangable boxes are allowed.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: adjustable.
 - 3. Shape: Rectangular.
 - 4. Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- F. Nonmetallic Floor Boxes: Nonadjustable, rectangular.
 - 1. Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- I. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 12, with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures:
 - a. Material: Fiberglass.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, Type per installation location, with removable interior panel and removable front, finished inside and out with manufacturer's standard.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: IMC. Pathway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 - d. Gymnasiums
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT, and innerduct.
 5. Damp or Wet Locations: IMC.
 6. Pathways for Optical-Fiber and Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway, Plenum-type, communications-cable pathway, EMT.
 7. Pathways for Optical-Fiber and Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway Riser-type, communications-cable pathway, EMT.
 8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway, Riser-type, optical-fiber-cable pathway, Plenum-type, optical-fiber-cable pathway, General-use, communications-cable pathway, Riser-type, communications-cable pathway, Plenum-type, communications-cable pathway, EMT.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 nonmetallic units in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Pathway Size: 3/4-inch (21-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.
- C. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealants recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- E. Install surface pathways only where indicated on Drawings.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.3 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA/BICSI 568.
 - 3. TIA-569-D.
 - 4. NECA 101
 - 5. NECA 102.
 - 6. NECA 105.
 - 7. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. Comply with requirements in Section 270544.10 "Sleeves and Sleeve Seals for Security Pathways and Cabling" for sleeves and sleeve seals for communications.
- E. Label all security conduits with blue marking band or blue paint every 10 feet (9000 mm). Paint security junction box covers with paint manufactured by Benjamin Moore #791, Duron 5085A (Americana) or approved equivalent.
- F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within 12 inches (300 mm) of changes in direction. Utilize long radius ells for all optical-fiber cables.
- J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- L. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1 inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10 foot (3 m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.

3. Arrange pathways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 5. Change from nonmetallic conduit and fittings to IMC and fittings before rising above floor.
- M. Stub-ups to Above Recessed Ceilings and Conduit Terminations at Cable Trays:
1. Use EMT, IMC, or RMC for pathways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- O. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- Q. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- S. Cut conduit perpendicular to the length. For conduits of 2 inch (50 mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- T. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200 lb (90 kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- U. Surface Pathways:
1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings (Telecommunications Only).
 2. Install surface pathway with a minimum 2 inch (50-mm) radius control at bend points.
 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- V. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. ¾ Inch (21 mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
2. 1 Inch (25 mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

W. Fabric Pathways for Optical-Fiber-Cable:

1. Install per manufacturer's recommendations and guidelines.
2. Provide textile innerduct in conduit and wire ways, and place textile innerduct within and under cable trays using continuous, unspliced lengths of textile innerduct between maintenance holes, pull boxes, and/or termination points as indicated on the Drawings.
3. Do not fasten textile innerduct to steam, water, or other piping, ductwork, mechanical equipment, electrical equipment, electrical raceways, or wires.
4. Cable Tray and Runway Installation: Cut incisions every 24 inches (61 cm) into the edge of the textile innerduct and cable wrap to one side of vertical ladder rack or horizontal ladder-type cable tray at each incision.

X. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.

Y. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service pathway enters a building or structure.
3. Where otherwise required by NFPA 70.

Z. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.

AA. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

- a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F (0.0115 mm per meter of length of straight run per deg C) of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- BB. Hooks (Telecommunications Only, Not allowed for Security):
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 4. Space hooks no more than 5 feet (1.5 m) o.c.
 5. Provide a hook at each change in direction.
- CC. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- DD. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- EE. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- FF. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- GG. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

HH. Set metal floor boxes level and flush with finished floor surface.

II. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544.10 "Sleeves and Sleeve Seals for Security Pathways and Cabling."

3.5 FIRESTOPPING

A. Comply with requirements in Section 078413 "Penetration Firestopping." Do not begin installation work until certificates of conformance or compliance, manufacturer's catalog data, and details for fire stopping of penetrations and joint systems showing compliance with the appropriate UL Design Number are approved by the Office of Safety Health and Environmental Management Fire Protection Engineer.

3.6 PROTECTION

A. Protect coatings, finishes, and cabinets from damage or deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528.10

SECTION 27 0553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

- A. This section provides the minimal requirements for the installation methods for the identification of communication cabling and components.
- B. Any client-specific labeling standards supersede this specification section.

1.2 DEFINITIONS

- A. For additional Definitions refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SYSTEM DESCRIPTION

- A. An effective system of identification for communications systems begins with clear, concise, and durable labeling. This system will serve to assist in efficiently establishing connectivity, troubleshooting, reconfiguration, and replacement of components a part of the communications Structured Cabling System (SCS).
- B. The work shall include materials, equipment, and apparatus not specifically mentioned herein or noted on the plans, but are necessary to effectively install the outlined identification on all new and existing Structured Cabling System (SCS) components outlined below.

1.5 SUBMITTALS

- A. Contractor to provide submittal with intended labeling scheme and labeling materials prior to execution of scope.
- B. Refer to Section 27 05 00 – Common Work Results for Communications

1.6 QUALITY ASSURANCE

- A. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed.

- B. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing data cabling.

PART 2 PRODUCTS

2.1 REQUIREMENTS AND HARDWARE

- A. Labels:
 - 1. As recommended in ANSI/TIA 606. Permanent (i.e., not subject to fading or erasure), permanently affixed, and created by a hand-carried label maker or a computer/software-based label making system. Handwritten labels are not acceptable.
 - a. For Station Cable:
 - 1) Brady: Bradymarker Wire Marking Labels WML-511-292 (or approved equal)
 - b. For Backbone Cable:
 - 1) Panduit Marker Tie (or approved equal)
- B. Hand-carried label maker:
 - 1. Brady: ID Pro Plus (or approved equal)

PART 3 EXECUTION

3.1 LABELING AND ADMINISTRATION

- A. General:
 - 1. Labeling and administration shall comply with ANSI/TIA 606 and standard industry practices.
 - 2. Before applying the cable numbering scheme described below, verify that the room numbers shown on the drawings match the actual room numbers that appear on building signage. The room numbering scheme may change between design and construction. All labeling and numbering schemes that incorporate room numbers shall reflect the finished, as-built room numbering, which may be different than the numbering shown in the construction documents.
- B. Racks and Cabinets:
 - 1. Label racks as shown on the Contract Documents. Affix label centered across top cross-member of rack.
- C. Telecommunications Bonding Busbars
 - 1. Label PBB(s) with "PBB-" suffixed with the ID of the telecommunications space which contains the PBB.
 - 2. Label SBB(s) with "SBB-" suffixed with the ID of the telecommunications space which contains the PBB.
- D. Grounding/Bonding Conductors:
 - 1. Label bonding conductors; "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"
- E. Backbone Cables:

1. Label Location: Affix labels at each end of the cable, within 6 feet of telecommunications room entrance and again within 12" of termination point.
 2. All fiber links will be labeled with wireclosetroom#-room@[a-z].
- F. Fiber Optic Patch Panels:
1. Fiber optic patch panels shall be labeled on the face of the patch panel with a sequential alpha lettering ("A", "B", "C", etc.) across all patch panels in the telecommunications room. Skip letters "I" and "O" to avoid future misinterpretation of them as the numbers one and zero.
 - a. For example: The first Fiber Optic Patch Panel in the room shall be labeled "Fiber Optic Patch Panel A" and the second shall be labeled "Fiber Optic Patch Panel B." Do not restart the lettering for patch panels in different racks.
 2. Connector panels (bulkheads) in fiber optic patch panels shall be labeled on the face of the fiber termination box with the same identifier as the cable that terminates in the connector panel. See paragraph A above.
- G. Horizontal Cables:
1. Label Location: Affix at each end of the cable.
 2. Station Cables: Label station cables with the same label as the station connector (see STATION CONNECTORS (PORTS) below) that terminates the cable at the station location. Include a clear vinyl adhesive wrapping applied over the label in order to permanently affix the label to the cable. Using transparent tape to affix labels to cables is not acceptable.
 3. Provide labels at each end of each cable within 24" of the patch panel at the telecommunications room end and within 6" of the jack at the work area outlet end.
 4. All copper pairs will be labeled with the wireclosetroom#-room@[a-z].
- H. Copper Horizontal Distribution Patch Panels (Workstation Patch Panels):
1. Patch panels shall be labeled on the face of the patch panel with a sequential alpha lettering ("A", "B", "C", etc.) across all patch panels in the telecommunications room. Skip letters "I" and "O" to avoid future misinterpretation of them as the numbers one and zero.
 - a. Lettering shall start at the topmost panel in the 1st rack designated for cabling.
 - b. Lettering should be placed on the left side of the panel, centered.
 - c. Do not restart the lettering for patch panels in different racks.
 - d. Minimum 1" width adhesive nylon fabric thermal transfer label. Black on white, maximum font size.
 2. Patch Panels should be labeled identifying the associated switch blade. (eg. BLADE 7) or associated switch (e.g. SWITCH #1).
- I. Termination Blocks:
1. General:
 - a. Label termination block ports/pairs sequentially beginning on the first row of each termination block column. Begin with "001" for the first port/pair.
 - b. Label termination strip pairs sequentially (left to right).
 2. For Horizontal Distribution:
 - a. Label station outlets in accordance with TIA-606 using typed or computer printed labels that fit the jack insert and are consistent with the patch panel labeling in the Telecommunications Room. (I.E. The top label on the faceplate of the first outlet from the First Floor A Telecommunications Room will be

01A-001-A, B and the bottom label on the same outlet will be blank. Label jacks as follows:

- 1) First and second character – The floor designator of the Telecommunications Room, 01, B3, LL.
 - 2) Third character – Telecommunications Room Designator, A.
 - 3) The fourth character is a hyphen (-).
 - 4) Fifth, sixth, and seventh character – a three-digit number identifying each outlet, numbered sequentially.
 - 5) The eighth character is a hyphen (-).
 - 6) The ninth (and possibly tenth and eleventh) character(s) – ‘A, B’ or ‘M’ based on the position/type of the port in the outlet.
- b. Label cables and patch panels with designations that are the same as the outlet.
 - c. Outlets shall be numbered on the patch panels sequentially starting with 001. DO NOT skip outlet numbers on the patch panels. If a pre-numbered outlet has been deleted, leave that position blank on the patch panel.
- J. Conduits:
1. Label each conduit end (existing or new) in a clear manner by designating the location of the other end of the conduit (i.e., room name, telecommunications room identifier, pull box identifier, outlet identifier (use the label of the first port of the outlet as the outlet identifier), etc.). Indicate conduit length on the label.
- K. Pull Strings:
1. Label each pull string in a clear manner by designating the location of the other end of the pull string (i.e., room name, telecommunications room name, pull box identifier, outlet identifier (use the label of the first port of the outlet as the outlet identifier), etc.).
- L. Telecommunications Rooms:
1. Affix a permanent label with the telecommunications room number on the wall above the light switch inside each telecommunications room. Where telecommunications room names are required in other labels, use the room number assigned to the telecommunications room and as shown on the room signage as-constructed. Also include the telecommunications identification for the room on the label as indicated in the Construction Documents.
- M. Racks:
1. Label racks in the form of “Floor Of TR, Compass Location, Rack #.” The sequential rack number given within a telecommunications room number left to right while facing the front of the racks. Affix label centered across top cross-member of rack.

END OF SECTION - 27 05 53

SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide all materials and labor for the installation of telecommunications cabinets, racks, frames, enclosures, cable management, and power hardware. This section includes hardware that supports the specified Structured Cabling System.
- B. Products installed (but not furnished) under this section:
 - 1. Grounding Conductor

1.2 DEFINITIONS

- A. For additional definitions, refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SYSTEM DESCRIPTION

- A. Furnish, install, test and place into satisfactory and successful operation all equipment, materials, devices, and necessary appurtenances associated with telecommunications cabinets, racks, frames, enclosures, cable management, and power hardware to support a communications Structured Cabling System (SCS) that is NEC compliant, ANSI/TIA/EIA compliant, and ISO/IEC compliant as shown on the Contract Documents.
- B. The work shall include all materials, equipment, and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant Structured Cabling System.

1.5 SUBMITTALS

- A. Make submittals in accordance with:
 - 1. Section 00 00 00 - Procurement and Contracting Requirements
 - 2. Section 01 33 00 - Submittal Procedures.
 - 3. Section 27 05 00 - Common Work Results for Communications

1.6 QUALITY ASSURANCE

- A. Contractor Warranty:

1. Provide a Contractor-endorsed one-year service warranty against defects in materials and workmanship.
 - a. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
 - b. The Contractor Warranty period shall commence upon Owner acceptance of the work.
- B. Listing and Labeling: Provide racks, fittings and accessories specified in this Section that are listed and labeled.
 1. The Terms "Listed" and "Labeled": As defined in NEC, Article 100.
 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- C. Comply with NECA's "Standard of Installation."
- D. Comply with NEC.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Racks, rack cable distribution hardware, ladder rack, and other rack and distribution components shall be manufactured by a single manufacturer unless stated otherwise in this Specification or in the Contract Documents. Do not intermix equipment and components between different manufacturers.
 1. Rack/Distribution Equipment:

2.2 MATERIALS

- A. CABLE SUPPORTS
 1. Backboards:
 - a. $\frac{3}{4}$ inch A-C grade, fire-retardant plywood backboards, void free, 8 feet high, unless otherwise noted.
 - b. Primer
 - c. White non-conductive paint, 2 coats.
 2. D-Rings:
 - a. Metallic:
 - 1) Large (16 square inch Capacity): CPI 10943
 3. Ladder Rack: Complete with fittings including (but not limited to) splice kits, cable radius drops, radius bends, protective end caps, retaining posts, support brackets, foot kits, vertical wall brackets, wall angles, grounding hardware and other incidental and miscellaneous hardware required for a complete ladder rack system. Ladder rack components shall be manufactured by the selected Rack/Distribution Equipment manufacturer.
 - a. Unless otherwise indicated, all ladder rack and incidental equipment color shall be white.
 - b. Ladder rack:
 - c. Horizontal radius bends:
 - d. Cable Retaining Posts (8 inch-high):
 - e. Radius Drops:

- f. Triangle Support Wall-bracket for Cable runway:
- g. Wall Angle Support bracket for Cable runway:
- h. Vertical Wall Support bracket for Cable runway:
- i. Ladder rack/cable runway Grounding kits:
- j. Ladder rack/cable runway Elevation kits:
- k. Ladder rack/cable runway end kits:
 - 1) End Closing Kit:
 - 2) End Caps:
- l. Other factory-manufactured appurtenances as necessary.
- B. EQUIPMENT RACKS/ENCLOSURES
 - 1. Unless otherwise indicated, equipment racks/enclosures and incidental equipment color shall be white.
 - 2. Unless otherwise indicated, equipment rack/enclosure/wall-mounted brackets and incidental materials and equipment shall be provided by the selected Rack/Distribution Equipment manufacturer. Do not intermix products from different manufacturers.
 - 3. Wall mounted Equipment Cabinets: TIA conforming wall mount, swing out fully enclosed cabinet with 2-pairs of 12-24 tapped sliding rails. Equip all cabinets with listed accessories.
 - a. Accessories: All accessories shall be of the same manufacturer as the selected equipment cabinets and have been manufactured for use within the selected product.
 - 4. Rack and Cabinet Accessories
 - a. Single sided low-profile equipment shelf
 - 5. Grounding kit and #6 AWG (insulated or bare) copper conductor grounded to the nearest PBB or SBB:
 - a. Screws, washers and nuts that are UL rated for use with grounding and bonding and able to break through painted surfaces to the metal substrate.
 - 6. Incidental materials required for proper construction, mounting and securing.
- C. GROUNDING AND BONDING
 - 1. As specified under Division 27 Section 27 05 26 – Grounding and Bonding for Communications Systems.

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
- B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NEC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.
- C. All work shall comply with the standards, references and codes listed in PART 1 -- REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.

- D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
- E. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.
- F. Remove surplus material and debris from the job site and dispose of it legally.

3.2 INSTALLATION

A. CABLE SUPPORTS

- 1. Backboards: Provide backboards as shown on Contract Documents. Backboards shall be capable of supporting attached equipment. Mount A-C plywood backboards with the "A" side exposed.
 - a. Paint backboards with a minimum of two coats (over primer) of non-conductive paint.
 - b. Mask the fire-treatment stamp on each sheet of plywood so that the stamp remains visible after painting.
- 2. D-Rings: Provide D-Rings as necessary to route exposed cables in telecommunications rooms and on backboards and for raceway for routing cable in non-exposed open access environments, and as shown in the Contract Documents. D-Rings may be affixed to wall/ceiling structures or other supports, but not attached to a ceiling support system. In telecommunications rooms, mount D-Rings at 12-inch intervals and as shown in the Contract Documents.
 - a. Size D-Rings as noted in the Contract Documents.
 - b. Where not noted, size D-Rings according to the type and quantity of cable to be routed through the ring per TIA/EIA 569 cable capacity standards, plus an additional 50% for future expansion, but not less than a minimum of 2 inches in diameter.
 - c. D-Rings are not permitted outside of telecommunications rooms unless otherwise indicated in the Contract Documents.
- 3. Ladder Rack: Provide ladder racking, sized and in locations as shown on the Contract Documents, installed per manufacturer's instructions with flat (rung) side up. Install ladder rack affixed to top of equipment racks to serve as equipment rack bracing.
 - a. Cut the ends of ladder rack square. Ream cut ends to remove burrs and sharp edges. Cap cut ends with manufacturer's recommended caps.
 - b. Provide 90-degree horizontal radius bends for each 90-degree change in direction of ladder rack angle.
 - c. Provide cable runway grounding kits across ladder rack splices and where ladder racks are connected to equipment racks/cabinets.
 - d. Provide cable retaining posts at each corner and junction, and wherever needed to manage cabling and innerduct, as follows:
 - 1) The inside of ladder rack (away from wall), where rack is mounted adjacent to a wall.
 - 2) Both sides of ladder rack where rack is not mounted adjacent to a wall.

- e. Where ladder rack is shown vertically mounted on telecommunications room walls, provide wall-mount brackets. A vertical ladder rack shall be routed from within 6-inches above the riser pathway in the floor up to within 6-inches of the riser pathway in the ceiling. Cap cut ends of ladder rails with end caps.

B. EQUIPMENT RACKS/ENCLOSURES

- 1. Provide EIA racks/cabinets and all associated hardware according to locations, elevations, and plan views as shown in the Contract Documents.
- 2. Free-standing Equipment Racks and Cabinets:
 - a. Bolt racks and cabinets to structurally suitable flooring.
 - b. Ensure that designated power outlets are installed in the vertical cable management as designed. The telecommunications installer shall work with the electrician to coordinate the power conduit routing and outlet box locations to be cooperative and compatible with the rack and equipment layout.
 - c. Attach top of rack to overhead ladder racking per manufacturer's recommendations. Use ladder rack elevation kits to span the gap between the top of the racks and the overhead ladder rack.

C. GROUNDING AND BONDING

- 1. Grounding and bonding work shall comply with the Uniform Building Code, Uniform Fire Code, UAC, National Electrical Code, and UL 467, ANSI/TIA/EIA standards and the references listed in PART 1 – REFERENCES above, as well as local codes which may specify additional grounding and/or bonding requirements.
 - a. Provide a minimum of one wall-mountable telecommunications ground busbar per telecommunications room and as shown on the Contract Documents.
 - b. Grounding conductor shall be installed to bond all non-current carrying metal telecommunications equipment and materials to the nearest PBB or SBB (as provided under Division 27 Section — “Grounding and Bonding for Communications Systems”).
 - 1) Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.
 - 2) Provide ladder rack grounding kits to bond each section of ladder rack and bond ladder rack to racks/cabinets where ladder racks are connected.
- 2. Refer to Section 27 05 26 - Grounding and Bonding for Communications Systems for additional requirements.

3.3 LABELING AND ADMINISTRATION

- A. Refer to Section 27 05 53 - Identification for Communications Systems for all Labeling materials and procedures.

END OF SECTION

SECTION 27 1500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide all materials and labor for the installation of an inside plant telecommunication system. This section includes Inside Plant Communications cabling, termination, and administration equipment, and installation requirements for the specified Structured Cabling System (SCS - See Definition Below).

1.2 DEFINITIONS

- A. For additional Definitions refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SYSTEM DESCRIPTION

- A. Furnish, install, test, and place into satisfactory and successful operation all equipment, materials, devices, and necessary appurtenances to provide a complete communications Structured Cabling System (SCS) that is compliant with ANSI/TIA/EIA, NECA/NEIS, and ISO/IEC standards as hereinafter specified and/or shown on the Contract Documents. The system is intended to be capable of integrating voice, data, and video signals onto a common media, and shall be tested for and be capable of 10 Gigabit Ethernet operation as specified in TIA/EIA 568.2-D, ISO/IEC 11801-1:2017, and ISO/IEC 11801-2:2017.
- B. The work shall include all materials, equipment, and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working ANSI/TIA/EIA and ISO/IEC compliant SCS.

1.5 SUBMITTALS

- A. Refer to Section 27 00 00 – Communications General

1.6 QUALITY ASSURANCE

- A. Contractor Warranty:
 - 1. Provide a Contractor-endorsed two-year service warranty against defects in materials and workmanship.

- a. Provide labor attributable to the fulfillment of this warranty at no cost to the Owner.
 - b. The Contractor Warranty period shall commence upon Owner acceptance of the work.
- B. All cable and equipment shall be installed in a neat and workmanlike manner. All methods of construction that are not specifically described or indicated in the contract documents shall be subject to the control and approval of the Owner or Owner Representative. Equipment and materials shall be of the quality and manufacture indicated. The equipment specified is based upon the acceptable manufacturers listed.
- C. Strictly adhere to all Building Industry Consulting Service International (BICSI), Electronic Industries Alliance (EIA) and Telecommunications Industry Association (TIA) recommended installation practices when installing data cabling.

1.7 SEQUENCING

- A. Provide coordination with the cabling manufacturers to ensure that manufacturers' inspectors are available to schedule site visits, inspections, and certification of the system. Provide and coordinate any manufacturer-required modifications and have manufacturer re-inspect and certify the system prior to the scheduled use of the system by the Owner.
- B. The Contractor is solely responsible for all costs associated with scheduling the manufacturer inspection, the inspection itself and any manufacturer-required re-inspections, and for any modifications to the installation as required by the manufacturers.

PART 2 - PRODUCTS

2.1 GENERAL

- A. SCS components shall be manufactured by the manufacturers listed below. Components shall not be intermixed between different manufacturers unless the manufacturer of the SCS has listed (in writing) another manufacturer's component as an "Approved Alternative Product" and will warrant the "Approved Alternative Product" as part of the SCS Manufacturer Warranty (see PART 1 - WARRANTY).
 1. Bid only the following SCS Manufacturers, and only bid manufacturers for which the Contractor is certified. The SCS Manufacturers shall be the following.
Substitution is not acceptable:
 - a. Copper Backbone Cabling, Patch Panels and Terminations:
 - 1) Legrand/Ortronics
- B. SCS Cables and Modular Jacks shall be color coded according to their intended use throughout the system. These colors are:

2.2 MATERIALS

- A. PATCH PANELS
 1. Copper Horizontal Distribution Patch Panels (Workstation Patch Panels):
Complete with pre-manufactured cable management for supporting station cable behind the patch panel, and with incidental materials necessary for mounting.

Terminations shall include universally color-coded wiring pattern for both T568A and T568B. Shall exceed the transmission performance requirements for connecting hardware, as specified in TIA/EIA 568.2-D, ISO/IEC 11801-1:2017 and ISO/IEC 11801-2:2017. Copper patch panels shall be manufactured by the selected SCS Manufacturer and be compatible with the selected modular jacks.

B. CONNECTORS

1. Data Copper Connectors (modular jacks): 8-position/8-conductor, insulation displacement connection (IDC), non-keyed, and shall accept modular 8-position/8-conductor plugs, and with a universally color-coded wiring pattern for both T568A and T568B. Shall exceed the transmission performance requirements for connecting hardware, as specified in TIA/EIA 568.2-D, ISO/IEC 11801-1:2017 and ISO/IEC 11801-2:2017:
 - a. Category 6/6A:
 - b. Category 6A:

C. STATIONS

1. Faceplates: Complete with port identification labels and blank inserts/fillers for covering unused connector openings. Coordinate colors with architectural finishes:
 - a. Faceplate Kits for outlets mounted to single gang faceplates on square backboxes.
 - 1) 4-Port:

D. CABLE

1. Cables shall be manufactured by the selected SCS Manufacturer.
2. Cables shall be rated for the environment for which they are being installed.
3. Copper Cable: 4-pair UTP, 23 AWG, NEC/NFPA CMP or CMR rated, with solid copper conductors.

- E. Hook and Loop Cable Managers: Reusable hook and loop (similar to Velcro) style, 5/8" wide, 15-foot- long roll, black.

PART 3 - EXECUTION

3.1 GENERAL

- A. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances.
- B. All work shall comply with applicable safety rules and regulations including OSHA. All work shall comply with the requirements of the National Electrical Safety Code (NESC) and the NEC except where local codes and/or regulations are more stringent, in which case the local codes and/or regulations shall govern.
- C. All work shall comply with the standards, references and codes listed in PART 1 -- REFERENCES above. Where questions arise regarding which standards, references, or codes apply, the more stringent shall prevail.
- D. All work shall comply with the requirements and recommendations of the product manufacturers. Where questions arise regarding which requirements and recommendations apply, the more stringent shall prevail.
- E. Replace and/or repair to original (or better) condition any existing structures, materials, equipment, etc. inadvertently demolished or damaged by the Contractor during the course of construction at no additional cost to the Owner.

- F. Remove surplus material and debris from the job site and dispose of legally.

3.2 INSTALLATION

A. PATCH PANELS

1. Provide patch panels and horizontal wire management according to locations, elevations, and plan views as shown on the Contract Documents.
 - a. Copper: Size and install rack-mounted patch panels as shown on the Contract Documents. Use patch panels to terminate copper horizontal cables.
 - b. Cable Management Bars:
 - 1) On the rear of the rack, provide cable management bar for each copper patch panel to support cables being terminated on the back of the patch panel.
 - 2) On the front of the rack, provide cable management bar between patch panels for patch cord lacing, as indicated on the rack elevation diagrams.

B. CONNECTORS

1. Copper Connectors (modular jacks):
 - a. Provide Data connectors and install using T568B wiring pattern.
 - b. Punch down cable using only the selected SCS Manufacturer-approved impact tool.
2. Copper Plugs:
 - a. Provide Data plugs only for specifically designated field-connectorized applications and install using T568B wiring pattern.
 - b. Terminate cables using manufacturer-approved tools and methods.

C. STATIONS

1. Faceplates: Provide faceplates for stations in the locations and gang counts shown on the Contract Documents. Faceplates shall completely conceal outlet boxes, reducer plates, etc. Faceplates shall provide a snug and sure fit for connectors – loose connectors are not acceptable. See diagram below for jack ordering and arrangement.
2. Flush-mount connectors in faceplates. For all outlets mount all connectors in 90-degree (straight) orientation (not angled).

D. CABLE

1. Plenum-rated vs. non-plenum-rated cabling: Most horizontal cabling applications at Clemson facilities are designed to permit non-plenum-rated cabling. If a cable is run entirely via conduit and junction boxes or does not pass through a plenum-rated space, then provide non-plenum (CM/CMR, OFNR) rated cable. Otherwise, provide plenum (CMP, OFNP) rated cable. Cabling shall bear plenum or non-plenum markings for the environment in which it is installed.
2. Wet applications: Provide indoor/outdoor, plenum-rated cabling to all outdoor horizontal applications and all applications where the cabling passes through conduit in or under a slab-on-grade floor. Terminate this cabling in the telecommunications room without intermediate splicing or consolidation point. Floor boxes in upper floors (above the slab-on-grade floor) are not considered wet applications.
3. All cabling:

- a. Do not paint cabling. Painted cabling will not be covered by the manufacturer's warranty.
- b. Provide horizontal cable in types, sizes, and quantities as defined by the Symbol Schedule and as shown on the Contract Documents. Install cabling between the station and its associated telecommunications room and patch panel. Provide one cable for each data connector at each station. Unless otherwise specified, provide white-colored cables.
- c. Install cable in compliance with ANSI/TIA/EIA and ISO/IEC 11801 requirements and BICSI TCIM practices.
- d. Adhere to the bending radius and pull strength requirements as detailed in the ANSI/TIA/EIA standards and the manufacturer's installation recommendations during cable handling and installation.
 - 1) Pull all cables simultaneously where more than one cable is being installed in the same raceway.
 - 2) Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation (Polywater or approved equal).
 - 3) Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage media or raceway. Repair or replace conduit bushings that become damaged during cabling installation.
- e. Install cable in a continuous (non-spliced) manner unless otherwise indicated.
- f. Install exposed cable parallel and perpendicular to surfaces on exposed structural members and follow surface contours where possible.
- g. Tie or clamp cabling. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable. Install tie-wraps in conformance with the SCS manufacturer's installation recommendations. Do not over-tighten tie wraps or cause cross-sectional deformation of cabling.
- h. Support cabling through elevation changes greater than 24 inches.
- i. Provide service loops with a minimum length of 10 feet in the telecommunications rooms and 12" in cable tray at point of horizontal conduit termination.
 - 1) For cables that are within distance limitations, route cabling around telecommunications room before terminating, creating a usable service loop. For cables that would not otherwise meet distance limitations, do not route first around the room (do not provide this service loop).
- j. Cable in the telecommunications rooms:
 - 1) Lay cable neatly in upper ladder rack in evenly-sized loose bundles (no more than 24 cables per bundle) and loosely secure cabling to the ladder rack at regular intervals with cable manager straps. Do not use tie-wraps.
 - 2) Route cables to patch panels on racks via ladder rack, across top of rack and then down vertical cable management to patch panel.

4. Copper Cable:
 - a. The following tool shall be used to terminate all horizontal cabling: TE SL series termination kit, TE 1725150-1 or equal Commscope product. The use of any tool that is not provided by the manufacturer and recommended by the manufacturer for this purpose is prohibited.
 - b. Terminate all pairs within a cable. Un-terminated cable pairs are not acceptable.
 - c. For shielded cable, bond both ends of the metallic shield (or metallic strength) member to the nearest SBB (as furnished under Division 27 Section — “Grounding and Bonding for Communications Systems”).
 - d. Route station cable that is exposed (not in conduit) to comply with ANSI/TIA/EIA-569 requirements for avoiding potential EMI sources and as follows:
 - 1) 48 inch separation distance from motors or transformers
 - 2) 12 inch separation distance from conduit and cables used for electrical power distribution
 - 3) 5 inch separation distance from fluorescent lighting. In telecommunications rooms, raise pendant fluorescent light fixtures such that they are at least 12 inches away from copper cabling.
5. Provide hook-and-loop cable managers for managing horizontal cabling in the telecommunications rooms.

3.3 LABELING AND ADMINISTRATION

- A. Refer to Section 27 05 53 - Identification for Communications Systems for labeling requirements

3.4 TESTING

- A. Refer to Section 27 17 00 - Testing of Structured Cabling Systems for all testing requirements

END OF SECTION - 27 15 00

SECTION 27 1500.10 - COMMUNICATIONS HORIZONTAL CABLING FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UTP cabling.
2. Cable connecting hardware, patch panels, and cross-connects.
3. Telecommunications outlet/connectors.
4. Cabling system identification products.

B. Related Requirements:

1. Section 271300 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Section 280513 "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.2 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
2. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
3. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, Cabling Administration Drawings, and field testing program development] by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site. Test each pair of UTP cable for open and short circuits.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.
 - 1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.

2.2 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1 when tested according to test procedures of this standard.
- B. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Grounding: Comply with J-STD-607-A.

2.3 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Section 061000 "Rough Carpentry" for plywood backing panels.

2.4 UTP CABLE

- A. Description: 100-ohm, four-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
 - 1. Comply with ICEA S-90-661 for mechanical properties.
 - 2. Comply with TIA/EIA-568-B.1 for performance specifications.
 - 3. Comply with TIA/EIA-568-B.2, Category 6.
 - 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.

2.5 UTP CABLE HARDWARE

- A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- B. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- C. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: two (2) for each conductor in assigned cables.

- D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
 - 1. Number of Jacks per Field: One for each four-pair UTP cable indicated.
 - 2. Provide biscuit Jacks for Camera and Panel connection locations. Secure Biscuit Jacks to backplane in LSP enclosure.
- E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
- F. Patch Cords: Factory-made, four-pair cables in 36-inch (900 mm) lengths; terminated with eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.

2.6 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
 - 1. Biscuit Jacks: Provide biscuit Jacks for Camera and Panel connection locations. Secure Biscuit Jacks to backplane in LSP enclosure.

2.7 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with J-STD-607-A.

2.8 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.9 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.

- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters. Conceal pathways and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements in Section 270528 "Pathways for Communications Systems."
 - 3. Comply with requirements in Section 270536 "Cable Trays for Communications Systems."
- B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Install lacing bars and distribution spools.
 - 3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA/EIA-568-B.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. MUTOA shall not be used as a cross-connect point.
 - 5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.
 - 6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI ITSM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

E. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.3 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-B, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with J-STD-607-A.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
1. Administration Class: 2
 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration, including optional identification requirements of this standard.
- D. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- F. Cable and Wire Identification:
1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
 - b. Label each unit and field within distribution racks and frames.
 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
 6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

- G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Visually inspect UTP jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6, marking of outlets, cover plates, outlet/connectors, and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
5. UTP Performance Tests:
 - a. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Equal-level far-end crosstalk (ELFEXT).
 - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
 - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.

- b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 271500

SECTION 27 1700 - TESTING OF STRUCTURED CABLING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section (27 17 00) includes the minimum requirements for the test certification, identification, and administration of horizontal balanced twisted pair cabling and optical fiber cabling.
- B. The Contractor provides all labor, materials, tools, field-test instruments, and equipment required for the complete testing, identification, and administration of the work called for in the Contract Documents.
- C. In order to conform to the overall project event schedule, the cabling Contractor shall survey the work areas and coordinate cabling testing with other applicable trades.
- D. In addition to the tests detailed in this document, the Contractor shall notify the Owner or the Owner's representative of any additional tests deemed necessary to guarantee a fully functional system. The Contractor shall carry out and record any additional measurement results at no additional charge.

1.2 DEFINITIONS

- A. For additional Definitions refer to Section 27 05 00 - Common Work Results for Communications

1.3 REFERENCES

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.
- B. Related Documents and Sections:
 - 1. Section 00 00 00 – Procurement and Contracting Requirements
 - 2. Section 01 00 00 – General Requirements
 - 3. Section 27 05 00 – Common Work Results for Communications

1.4 SCOPE

- A. This Section includes the minimum requirements for:
 - 1. Identification, including labels and labeling
 - 2. Administration, including:
 - 3. Test results documentation
 - 4. As-built drawings
- B. The testing of copper cabling, including:
 - 1. Test instruments
 - 2. Test procedures
- C. The testing of fiber optic cabling, including:
 - 1. Test instruments
 - 2. Test procedures
- D. Testing shall be carried out in accordance with this document. The Contractor shall:

1. Test all installed balanced twisted pair cabling permanent links to the applicable performance level.
2. Test the attenuation and polarity of the installed optical fiber cable plant with an Optical Loss Test Set (OLTS)
3. Test the installed condition of the optical fiber cabling system and its components with an Optical Time Domain Reflectometer (OTDR)
4. Verify the condition of the fiber end faces
- E. The Contractor shall document all tests including:
 1. OLTS dual wavelength attenuation measurements
 2. OTDR traces with event tables and OTDR maps – Edit or remove this item as appropriate for the project.
 3. Optical length measurements and pictures of the connector end faces

1.5 OPTICAL FIBER TESTING

- A. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
- B. The manufacturer of the connectors and/or the cable
- C. The manufacturer of the test equipment used for the field certification
- D. Training organizations such as Building Industry Consulting Service International (BICSI), the Association of Cabling Professionals™ (ACP), the Cabling Business Institute (CBI)

1.6 OWNER'S PARTICIPATION

- A. The Owner or the Owner's representative shall be invited to witness and/or review field testing.
- B. Five business days before testing commences, the Owner or the Owner's representative shall be notified of the start date of the testing phase.
- C. The Owner or the Owner's representative shall:
 1. Select a random sample of five percent of the installed links
 2. Test these randomly selected links
 3. Store the results in accordance with Part 3 of this document
- D. The Contractor shall compare the results obtained by the Owner to the data provided by the installation Contractor. If more than two percent of the pass/fail determinations in the sample results differ from the data provided by the installation Contractor, the Contractor, under the supervision of the Owner's representative, shall repeat one hundred percent of the testing at no cost to the Owner.

1.7 SUBMITTALS

- A. The Contractor shall submit the following:
 1. The manufacturer's catalog sheets and specifications for the test equipment
 2. A schedule (list) of all links and channels to be tested
 3. Sample test reports
 4. The test equipment serial number

5. A graphic diagram documenting the test procedure, including all connectors, the light source (as applicable,) the origin, and the destination of each cable tested.
- B. TEST RESULTS
 1. Balanced Twisted Pair Links
 - a. Category-5E and Category-6 Balanced Twisted Pair
 - 1) Unless otherwise specified by the Owner or the Owners representative, each Category 5E and Category-6 balanced twisted pair cabling link shall be tested for:
 - 2) Wire Map
 - 3) Length
 - 4) Propagation Delay
 - 5) Delay Skew
 - 6) DC Loop Resistance
 - 7) DC Resistance Unbalance within a pair
 - 8) DC Resistance Unbalance between pairs
 - 9) Insertion Loss
 - 10) Near-End Crosstalk (NEXT)
 - 11) Power Sum Near-End Crosstalk (PS NEXT)
 - 12) Attenuation to Crosstalk Ratio Near-End (ACR-N)
 - 13) Power Sum Attenuation to Crosstalk Ratio Near-End (PS ACR-N)
 - 14) Attenuation to Crosstalk Ratio Far-End (ACR-F)
 - 15) Power Sum Attenuation to Crosstalk Ratio Far-End (PS ACR-F)
 - 16) Return Loss
 - 17) Transverse Conversion Loss (TCL)
 - 18) Equal Level Transverse Conversion Transfer Loss (ELTCTL)
 - b. Category-6A Balanced Twisted Pair
 - 1) Unless otherwise specified by the Owner or the Owners representative, each Category-6A link shall be tested for all of the parameters listed above for Category-5E and Category-6 as well as the following additional parameters:
 - 2) Power Sum Alien Near-End Crosstalk (PS ANEXT)
 - 3) Average Power Sum Alien Near-End Crosstalk (Average PS ANEXT)
 - 4) Power Sum Alien Attenuation to Crosstalk Ratio Far-End (PS AACR-F)
 - 5) Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Average PS AACR-F)
 - c. When a Balanced Twisted Pair Permanent Link Fails
 - 1) All installed balanced twisted pair cabling permanent links shall be field-tested and shall pass the test requirements and analysis described in Part 3.
 - 2) Any permanent link that fails these requirements shall be diagnosed and corrected.

- 3) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected permanent link meets performance requirements.
 - 4) The final and passing result of the tests for all permanent links shall be provided in the test results documentation, in accordance with Part 3.
2. Optical Fiber Links
- a. Test Limits – ANSI/TIA-568.3-D Singlemode (STD) and Multimode (STD)
 - b. Unless otherwise specified by the Owner or the Owners representative, each optical fiber cabling link shall comply with the following test limits:
 - 1) Optical loss testing
 - 2) Multi-mode and single-mode links
 - 3) Link attenuation calculated by the formulas, as specified in ANSI/TIA-568-C.0:
 - (a) $\text{Link Attenuation (dB)} = \text{Cable Attn (dB)} + \text{Connector Attn (dB)} + \text{Splice Attn (dB)}$
 - (b) $\text{Cable Attn (dB)} = \text{Attenuation Coefficient (dB/km)} * \text{Length (Km)}$
 - (c) $\text{Connector Attn (dB)} = \text{number of connector pairs} * \text{connector loss (dB)}$ Maximum allowable connector loss = 0.75 dB
 - (d) $\text{Splice Attn (dB)} = \text{number_of_splices} * \text{splice_loss (dB)}$ Maximum allowable splice_loss = 0.3 dB
 - 4) The values for the Attenuation Coefficient (dB/km) are listed in the table below. Where application limits are more stringent, those shall apply.

type of optical fiber	wavelength (nm)	attenuation coefficient (dB/km)	wavelength (nm)	attenuation coefficient (dB/km)
Multi-mode 62.5/125 μm	850	3.5	1300	1.5
Multi-mode 50/125 μm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

- c. OTDR Testing
 - 1) Reflective events (connections) shall not exceed the following limits. Where application limits are more stringent, those shall apply.
 - (a) dB in optical loss when bi-directionally averaged
 - (b) -35 dB reflectance for multi-mode connections
 - (c) -40 dB reflectance for UPC single-mode connections

- (d) -55 dB reflectance for APC single-mode connections
 - (e) Non-reflective events (splices) shall not exceed 0.3 db
 - d. Magnified End Face Inspection
 - 1) Fiber connections shall be visually inspected for compliance with IEC 61300-3-35 Edition 1.0 for end face quality.
 - 2) Scratched, pitted or dirty connectors shall be diagnosed and corrected.
 - e. When an Optical Fiber Link or Channel Fails
 - 1) All installed optical fiber cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3.
 - 2) Any link or channel that fails these requirements shall be diagnosed and corrected.
 - 3) Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements.
 - 4) The final and passing result of the tests for all links and channels shall be provided in the test results documentation, in accordance with Part 3.
- 3. Acceptance of Test Results
 - a. Once the project is fully completed and tested in accordance with the Contract Documents and to the satisfaction of the Owner, the Owner's acceptance of the test results shall be given in writing to the Engineer.

1.8 PROJECT ENVIRONMENTAL REQUIREMENTS

- A. Seismic Safety
 - 1. Observe mechanical and electrical support means for all installed equipment as required by all applicable local building codes for this installation's earthquake risk hazard zone and as recommended by Telcordia Specification GR-63.
 - 2. All equipment racks should to be anchored with suitable anchors that meet safety standards.
 - 3. Overhead devices should be mounted with appropriate safety attachments as required.
 - 4. Where cabinets and racks are secured directly to the building, this should be done in accordance with guidance provided by the Authority Having Jurisdiction (AHJ) or a structural engineer.
 - 5. Equipment and fixtures should have shock and vibration isolation.
- B. Fiber Optic Cable Safety
 - 1. The following warnings shall be posted on the job site:
 - a. WARNING: PERMANENT EYE DAMAGE CAN RESULT FROM LOOKING DIRECTLY INTO A LIGHT BEAM GENERATED BY AN LED OR LASER SOURCE OR INTO THE END OF A CABLE FIBER CONNECTED TO ONE OF THESE SOURCES.
 - b. CAUTION: LIGHT GENERATED BY THESE SOURCES MAY NOT BE VISIBLE YET REMAIN HAZARDOUS TO THE EYE. LOOK FOR WARNING LABELS ON SOURCE DEVICES.
 - 2. Observe all warning signs on equipment and all written safety precautions in the equipment instruction and technical manuals.

3. Always handle cable carefully to avoid personal injury. Care should be taken with individual fibers to prevent injury to the eyes or penetration of the fibers into the skin.
- C. Hazardous Materials Prohibition
 1. The Contractor shall make sure that all materials used in the project are asbestos-free, unless specifically authorized in writing by the Owner.
 2. Applicable products shall comply with the European directives on the Restriction of Hazardous Substances (RoHS; 2002/95/EC) and Waste Electrical and Electronic Equipment (WEEE; 2002/96/EC). – Only include this for facilities in Europe.

1.9 EXISTING CONDITIONS

- A. Verify that all conditions on the project site are acceptable for the Work specified in this Section. Prior to bid opening, notify the Consulting Engineer in writing of any discrepancies, conflicts, or omissions. Otherwise, correct these issues at no additional cost to the Owner.
- B. Continue to monitor the project site. If conditions develop that require a variance from the Specifications or Drawings, then immediately notify the Owner in writing. Otherwise, make recommendations, submit drawings showing how the Work may be installed, and upon approval, proceed with the necessary changes without additional cost to the Owner.

1.10 RECORD DRAWINGS

- A. Keep a complete set of all telecommunications drawings in the job site office for reference of the actual installation of work under this Section.
- B. Use this set of drawings for no other purpose.
- C. Where any material, equipment, or system components are installed differently than what is shown on the Drawings, indicate the differences clearly and neatly using ink or indelible pencil.
- D. Upon completion of the project, submit the record set of Drawings.

PART 2 - PRODUCTS

2.1 GENERAL

A.

2.2 MATERIAL

- A. BALANCED TWISTED-PAIR CABLE TESTERS
 1. The field test instrument shall be manufactured by Fluke Networks.
 2. The field test instrument shall have been calibrated within the last twelve months.
 3. There shall be independent verification that the field test instrument meets the following accuracy requirements:
 - a. For Category 5E, Level IIe accuracy in accordance with ANSI/TIA-1152
 - b. For Category 6, Level III accuracy in accordance with ANSI/TIA-1152
 - c. For Category 6A, Level IIIe accuracy in accordance with ANSI/TIA-1152
 4. Permanent Link Adapters

- a. The RJ45 plug must meet the requirements for NEXT, FEXT, and Return Loss in accordance with ANSI/TIA-568.2-D.
 - b. Twisted pair Category 5e, 6, 6A, 7, or 7A cords are not permitted, as their performance degrades with use and can cause false Return Loss failures.
 5. Results Storage
 - a. The field test instrument shall be capable of storing more than 10,000 results for all measurements found within this section.
 6. Measurement Capabilities for Category 5E and Category 6 Links
 - a. On Category 5E and Category 6 links, the field test instrument shall be capable of testing the following parameters:
 - 1) Wire Map
 - 2) Length
 - 3) Propagation Delay
 - 4) Delay Skew
 - 5) DC Loop Resistance
 - 6) DC Resistance Unbalance within a pair
 - 7) DC Resistance Unbalance between pairs
 - 8) Insertion Loss
 - 9) Near-End Crosstalk (NEXT)
 - 10) Power Sum Near-End Crosstalk (PS NEXT)
 - 11) Attenuation to Crosstalk Ratio Near-End (ACR-N)
 - 12) Power Sum Attenuation to Crosstalk Ratio Near-End (PS ACR-N)
 - 13) Attenuation to Crosstalk Ratio Far-End (ACR-F)
 - 14) Power Sum Attenuation to Crosstalk Ratio Far-End (PS ACR-F)
 - 15) Return Loss
 - 16) Transverse Conversion Loss (TCL)
 - 17) Equal Level Transverse Conversion Transfer Loss (ELTCTL)
 - 18) Time Domain Reflectometer
 - 19) Time Domain Crosstalk Analyzer
 7. Measurement Capabilities for Category 6A
 - a. On Category 6A links, the field test instrument shall be capable of testing all of the parameters listed above for Category 5E and Category 6 links and all of the following parameters:
 - 1) Power Sum Alien Near-End Crosstalk (PS ANEXT)
 - 2) Average Power Sum Alien Near-End Crosstalk (Average PS ANEXT)
 - 3) Power Sum Alien Attenuation to Crosstalk Ratio Far-End (PS AACR-F)
 - 4) Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Average PS AACR-F)
- B. PC Software
1. The field test instrument's PC software shall:
 - a. Be Windows® based
 - b. Show when 3 dB and 4 dB rules are applied
 - c. Have re-certification capability where results have "(RC)" added to the end of the Cable IDs

- d. Have a built-in PDF export capability, as no additional third party software is permitted
- e. Have built-in statistical analysis
- C. OPTICAL FIBER CABLE TESTERS
 - 1. The field test instrument shall have been calibrated within the period recommended by the manufacturer, and a copy of the calibration certificate shall be made available.
 - 2. Optical Loss Test Set (OLTS)
 - 3. Multi-Mode Optical Fiber Light Source
 - 4. The multi-mode optical fiber light source shall:
 - a. Provide dual LED light sources with central wavelengths of 850 nm (± 30 nm) and 1300 nm (± 20 nm). VCSEL sources are not permitted per ANSI/TIA-526-14-B.
 - b. Have output power of at least -20 dBm
 - c. Meet the Encircled Flux launch requirements of ANSI/TIA-526-14-B
 - d. Have test reference cords that demonstrate an insertion loss of 0.15 dB when mated against each other
 - e. Be manufactured by Fluke Networks
 - 5. The single-mode optical fiber light source shall:
 - a. Provide dual laser light sources with central wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).
 - b. Have output power of at least -10 dBm
 - c. Have test reference cords that demonstrate an insertion loss of 0.25 dB when mated against each other
 - d. Be manufactured by Fluke Networks
 - 6. Power Meter shall:
 - a. Provide test capability at wavelengths of 850 nm, 1300 nm, 1310 nm, and 1550 nm
 - b. Have power measurement uncertainty of ± 0.25 dB
 - c. Store reference power measurements
 - d. Save at least 10,000 results to internal memory
 - e. Have a USB PC interface
 - f. Be manufactured by Fluke Networks
 - 7. Optional Length Measurement
 - a. An OLTS capable of measuring the optical length of the fiber using time-of-flight techniques is preferable.
 - b. For MPO/MTP trunk cables, length shall be calculated using cable jacket length markings.
- D. Optical Time Domain Reflectometer (OTDR)
 - 1. The OTDR shall:
 - a. Have a color LCD display with backlight
 - b. Have rechargeable Li-Ion battery for 8 hours of normal operation
 - c. With battery and module, weigh no more than 4.5 pounds and have a volume of no more than 200 in²
 - d. Have internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally-tested fiber links
 - e. Have a USB port to transfer data to a PC or thumb drive/memory stick
 - f. Be manufactured by Fluke Networks

2. The multi-mode OTDR shall:
 - a. Provide test capability at wavelengths of 850 nm (± 10 nm) and 1300 nm ($+35$ nm / -15 nm)
 - b. Have event dead zones that do not exceed 0.7 m at 850 nm and 1300 nm
 - c. Have attenuation dead zones that do not exceed 2.5 m at 850 nm and 4.5 m at 1300 nm
 - d. Have distance range of at least 9,000 m
 - e. Have a dynamic range of at least 28 dB for 850 nm and 30 dB at 1300 nm
 - f. Allow bi-directional testing without moving the OTDR to the far end
3. The single-mode OTDR shall:
 - a. Provide test capability at wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm)
 - b. Have event dead zones that do not exceed 0.6 m at 1310 nm and 1550 nm
 - c. Have attenuation dead zones that do not exceed 3.7 m at 1310 nm and 1550 nm
 - d. Have distance range of at least 80 km at 1310 nm and 130 km at 1550 nm
 - e. Have a dynamic range of at least 32 dB for 1310 nm and 30 dB at 1550 nm
 - f. Allow bi-directional testing without moving the OTDR to the far end
- E. Fiber Microscope
 1. The fiber microscope shall:
 - a. Have a field of view of 420 μ m by 320 μ m
 - b. Have camera probe tips that permit inspection through adapters
 - c. Be capable of saving and reporting the end face image to IEC 613003-3-35
 - d. Be manufactured by Fluke Networks
 - e. Preferably be a video camera system
- F. Integrated OLTS, OTDR, and Fiber Microscope
 1. Test equipment that combines an OLTS, an OTDR, and a fiber microscope into one instrument may be used.
 2. Any such system shall be manufactured by Fluke Networks.

2.3 ADMINISTRATION

- A. Administration documentation shall include the test results of each permanent link.
- B. Upon completion of the test of each link, the test result information for that link shall be recorded in the memory of the field test instrument.
- C. The test result records saved in the field test instrument shall be transferred into a Windows®-based database utility that allows for the maintenance, inspection, and archiving of these test records.
- D. For additional information see Section 27 05 53

PART 3 - EXECUTION

3.1 GENERAL

- A. Prior to field-testing, all outlets, cables, patch panels, and associated components shall be fully assembled and labeled. Any testing performed on incomplete systems shall be redone after the systems are fully assembled and labeled.

- B. Cables and equipment that do not pass tests shall be identified and discussed with the Owner and Engineer. Determine the source of the non-compliance and replace or correct the cable or the connection materials, and retest the cable or connection materials at no additional expense to the Owner. Provide new test results to the Owner and Engineer in the same manner as above.
1. In addition to the above, if it is determined that the cable is at fault, remove the damaged cable and replace it with a new cable. Cable “repairs” are not acceptable. The procedure for removing the cable shall be as follows:
 - a. Prior to removal of damaged cable and installation of new cable:
 - 1) Inform the Owner and Engineer of the schedule for the removal and installation.
 - 2) Test cables that occupy the same innerduct or conduit (if not in innerduct) as the damaged cable per paragraph B, above, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
 - 3) Provide test results to the Owner and Engineer for approval by the Owner and Engineer.
 - b. Remove the damaged cable and provide new cable.
 - c. After the removal of the damaged cable and installation of the new cable:
 - 1) Test the new cable per the paragraph titled TESTING.
 - 2) Test cables that occupy the same innerduct or conduit as the damaged cable per paragraph B, above, regardless of whether they are new cables installed as part of this project or existing cables installed prior to this project.
 - 3) If any of the cables requiring testing are in use, coordinate with the Owner to schedule an outage opportunity during which the testing can be performed.
 - 4) Provide test results to the Owner and Engineer for approval by the Owner and Engineer.
 - d. If a cable which occupies the same innerduct or conduit as a damaged cable is damaged by the extraction and reinstallation process, replace the cable at no additional expense to the Owner.
 - 1) Damaged cables which are replaced shall be subject to the testing procedures of the paragraph titled TESTING.
- C. Upon completion of the work, a Registered Communications Distribution Designer (RCDD) shall submit as-built Drawings to the Owner or Owner’s representative.
1. Provide test records on a form approved by the Owner and Engineer. Include the test results for each cable in the system. Submit the test results for each cable tested, with identification as discussed under LABELING AND ADMINISTRATION above. Include the cable identifier, outcome of test, indication of errors found, cable length, retest results, and name and signature of technician completing the tests. Provide test results to the Owner and Engineer for review and acceptance within two weeks of Substantial Completion.
 - a. Print test records in Adobe PDF format for each cable directly from the test software and submit in electronic form (in Adobe PDF and native Fluke test

files) on CDROM to the Owner and Engineer for review. Handwritten test results will not be accepted.

- b. Any cabling discovered to have unsatisfactory test results shall be re-terminated or replaced and retested.
- c. After all performance and testing issues have been addressed, resubmit the complete set of corrected test reports to the Owner and Engineer on CDROM.

D. Submit test reports within seven (7) business days of completion of testing.

3.2 SYSTEM ADMINISTRATION

A. Test Results Documentation

1. At the end of each working day, upload the copper cable permanent link test results, except for alien crosstalk testing, to the associated PC software for inspection by the Owner or the Owner's representative.
2. Test results uploaded shall allow for the maintenance, inspection, and archiving of the test records.
3. Prior to the Owner accepting the project:
 - a. Store the database of the complete project, including, if applicable, fiber links, in the format native to the software.
 - b. Deliver the database to the Owner on CD, DVD, or thumb-drive.
 - c. To allow the Owner to inspect and print the test reports, include a working and fully-licensed copy of the software.
4. Circuit IDs reported by the test instrument should match the specified label ID. (See "LABELS" below)
5. Provide the detailed test results documentation data, in an electronic database, for each tested optical fiber and include the following information:
 - a. The identification of the customer site as specified by the end-user
 - b. The name of the test limit selected to execute the stored test results
 - c. The name of the personnel performing the test
 - d. The date and time that the test results were saved in the memory of the tester
 - e. The manufacturer, model, and serial number of the field test instrument
 - f. The version of the test software and the version of the test limit database held in the test instrument
 - g. The fiber identification number
 - h. The length of each optical fiber
 - i. The index of refraction used for length calculation when using a length-capable OLTS
 - j. The backscatter coefficient of the fiber under test when using an OTDR
 - k. The OLTS attenuation link and channel measurements at the appropriate wavelengths and the margin (the difference between the measured attenuation and the test limit value)
 - l. The OTDR link and channel traces, event tables at the appropriate wavelengths, and a map of the link tested
 - m. The length of each optical fiber, as calculated by the OTDR
 - n. The overall pass/fail evaluation of the link-under-test for OLTS and OTDR measurements
 - o. A picture or image of each fiber end-face
 - p. A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0

B. Testing of Category 5E and Category 6 Permanent Links

1. For each Category 5E and Category 6 balance twisted-pair permanent link, provide the detailed test results documentation data in the associated PC software including:
 2. The overall pass/fail evaluation of the link-under-test
 3. The date and time the test results were saved in the memory of the tester
 4. The identification of the customer site, as specified by the Owner
 5. The name of the test limit selected to execute the stored test results
 6. The name of the personnel performing the test
 7. The version of the test firmware and the version of the test limit database held in the test instrument
 8. The manufacturer, model, and serial number of the field test instrument
 9. The adapters used
 10. The factory calibration date
 11. A pair map
 12. Propagation delay values for all four pairs
 13. Delay skew values for all four pairs
 14. DC resistance values for all four pairs
 15. DC resistance unbalance within a pair values for all four pairs
 16. DC resistance unbalance between pairs values for all four pairs
 17. Insertion loss worst case values for all four pairs
 18. NEXT worst-case margin and worst-case values in both directions
 19. PS NEXT worst-case margin and worst-case values in both directions
 20. ACR-N worst-case margin and worst-case values in both directions
 21. PS ACR-N worst-case margin and worst-case values in both directions
 22. ACR-F worst-case margin and worst-case values in both directions
 23. PS ACR-F worst-case margin and worst-case values in both directions
 24. Return loss worst-case margin and worst-case values in both directions
 25. TCL worst-case margin and worst-case values in both directions
 26. ELTCTL worst-case margin and worst-case values in both directions
 27. Time domain crosstalk data, if the link is marginal or fails
 28. Time domain reflectometer data, if the link is marginal or fails

C. Testing of Category 6A Permanent Links

1. For each Category 6A balance twisted-pair permanent link, provide all of the same detailed test results documentation data required for Category 5E and Category 6 permanent links and also the detailed test results documentation data for alien crosstalk testing, in AxTalk Analyzer, including:
 2. PS ANEXT worst-case margin for all four pairs
 3. Average PS ANEXT worst-case margin
 4. PS AACR-F worst-case margin for all four pairs
 5. Average PS AACR-F worst-case margin

3.3 FIELD QUALITY CONTROL

A. General

1. The Owner reserves the right to be present during any or all of the testing.
2. All cabling not tested in strict accordance with these specifications shall be re-tested at no additional cost to the Owner.

3. 100% of the installed cabling must be tested. All tests must meet the acceptance criteria defined in the media specific sections of this document.
4. Prior to each day's testing, fully charge all test equipment and bring an appropriate alternate power source to the job site.
5. Throughout the testing, have a competent supervisor and supporting technical personnel, acceptable to the Owner, available on site. Changing the supervisor during the testing shall not be acceptable without prior written approval from the Owner.
6. Upon completion of the testing, it shall be the responsibility of the Contractor to perform the necessary adjustments and other controls to ensure proper system operation. The system shall be physically inspected by the Owner to assure that all equipment is installed in a neat and workmanlike manner as called for by the contract documents.
7. Verify the performance parameters of the individual systems, following established professional procedures, in addition to those specified herein. Document all acceptance testing, calibration, and correction procedures described herein, taking care to include the following information:
 - a. The date on which each procedure was performed
 - b. The reason that the procedure was performed
 - c. The type of and a description of the procedure
 - d. The parameters measured and their values, including, as applicable, the values measured prior to calibration or correction
 - e. The parameters associated with calibration or corrective networks, components, or devices
 - f. The names of the personnel conducting the procedure
 - g. The equipment used to conduct the procedure

END OF SECTION - 27 17 00

SECTION 28 0500.10 - COMMON WORK RESULTS FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

- A. Provide the electronic security system (ESS) in accordance with the drawings, specifications, and referenced publications.
- B. Perform all work, products, systems integration, engineering, and design work required for the project in order to ensure complete and fully operational systems and proper installation of equipment. Provide calculations and analysis to support design and engineering decisions as specified in submittals. Provide and pay all labor, materials, and equipment, sales and gross receipts and other taxes. Secure and pay for plan check fees, permits, other fees, and licenses necessary for the execution of work as applicable for the project. Give required notices; comply with codes, ordinances, regulations, and other legal requirements of public authorities, which bear on the performance of work.
- C. Provide an ESS, installed, programmed, configured, documented, and tested. The security system includes but is not limited to: access control, intrusion detection, duress alarms, video surveillance and assessment, video recording and storage, delayed egress, intercommunication system, fire alarm interface, equipment cabinetry, and uninterruptible power supplies (UPS) interface.
- D. The work includes the procurement and installation of electrical wire and cables, the installation and testing of all system components. Inspection, testing, demonstration, and acceptance of equipment, software, materials, installation, documentation, and workmanship, shall be as specified herein. Provide all associated installation support, including the provision of primary electrical input power circuits.
- E. Provide repair service replacement parts and on-site service during the warranty period. Guarantee all parts and labor for a term of one (1) year, unless dictated otherwise in this specification from the acceptance date of the system as described in specification 280800.10. The Contractor is responsible for all equipment, software, firmware, licensing, shipping, transportation charges, and expenses associated with the service of the system for one (1) year.
- F. Operator training is not required.

1.3 SUMMARY

- A. This specification provides general requirements for the overall electronic security system (ESS) applicable to all projects.

1.4 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. This Specification is the base document for electronic security systems. Use the following specification sections in conjunction to provide a complete and fully integrated security management system.

1. 27 0526.10 – Grounding and Bonding for Security Systems
2. 27 0528.10 – Pathways for Security Systems
3. 27 0536.10 – Cable Trays for Security Systems
4. 27 0544.10 – Sleeves and Sleeve Seals for Security Pathways and Cabling
5. 27 1116.10 – Security Cabinets, Racks, Frames, and Enclosures
6. 27 1300.10 – Security Backbone Cabling
7. 27 1500.10 – Security Horizontal Cabling
8. 28 0500.10 – Common Work Results for Electronic Security
9. 28 0507.10 – Power Sources for Electronic Security
10. 28 0509.10 – Surge Protection for Electronic Security
11. 28 0531.10 – Communications Equipment for Electronic Security
12. 28 0800.10 – Commissioning of Electronic Security
13. 28 1000 – Access Control
14. 28 1515 – Electrified Locking Devices & Accessories
15. 28 2000 – Video
16. 28 3100 – Intrusion Detection
17. 28 3111 – Addressable Fire Alarm System

- C. Requirements of Specification 280800.10 take precedence over Division 01 System Acceptance requirements.

- D. Related Sections include the following:

1. Division 01
2. Division 08
 - a. Coordinate Division 8 and 28 requirements.
3. Division 12
 - a. Coordinate case mounted security sensors and equipment.

4. Division 14
 - a. Elevator Contractor shall coordinate and install equipment in the elevator. The equipment includes the intercoms, cameras, and card readers.
 - b. Terminate signal lines in the elevator machine room for use by the Security Contractor.
 - c. Security Contractor shall coordinate cabling. Use High Flex cables for elevator installations listed for intended purpose.
 - d. The Security Contractor shall provide terminal strips and wire from the security panel, labeling each point and its respective function (input output) for the Elevator Contractor shall provide final termination from elevator panel.
 - e. Provide a transition box for all security related equipment.
5. Division 23
 - a. Coordinate installation of the Light Control Equipment, Radio, and Elevator Status Equipment installed in the Security Monitoring Console. Provide dedicated Liebert Cooling Systems (or approved equivalent) and controls, for each Security Monitoring Control and Equipment room.
6. Division 26
 - a. Provide dedicated Emergency Electrical Power (120 VAC) circuits as required to provide full system functionality.
7. Division 27
 - a. Shared pathways
 - b. Security Cabling
 - c. Grounding and Bonding System

1.5 REFERENCES

- A. American National Standards Institute (ANSI)
 1. ANSI INCITS 92 (1980, R 2003), Data Encryption Standard
 2. ANSI/TIA-568.0-D, Rev D (9/2015+Edit:12/2015) , Generic Telecommunications Cabling for Customer Premises
 3. ANSI/TIA-568.1-D, Rev D (9/2015), Commercial Building Telecommunications Infrastructure Standard
 4. ANSI/TIA-568-C.2, Rev C (8/2009+A1:6/2016), Balanced Twisted-Pair Telecommunications Cabling And Components Standards
 5. ANSI/TIA-568-C.3, Rev C (6/2008+A1:10/2011), Optical Fiber Cabling Components Standard

6. ANSI/TIA-568-C.4, Rev C (7/2011), Broadband Coaxial Cabling and Components Standard
7. ANSI/TIA-569, REV D (4/2015), Telecommunications Pathways and Spaces
8. ANSI/TIA-606, Rev B (6/2012+A1:12/2015), Administration Standard for the Telecommunications Infrastructure
9. ANSI/TIA-607, Rev C (11/2015), Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
10. ANSI/TIA/EIA 492AAAB Rev B (11/2009), Detail Specification for 50µm Core Diameter / 125µm Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
11. ANSI/TIA/EIA-526-14 Revision C (4/2015), Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant; Modification of IEC 61280-4-1 edition 2, Fiber-Optic Communications Subsystem Test Procedures- Part 4-1: Installed Cable Plant-Multimode Attenuation Measurement
12. ANSI/SIA CP-01-2014, Control Panel Standard - Features for False Alarm Reduction

B. ASTM International (ASTM)

1. ASTM A153/A153M-16, Standard Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
2. ASTM B3-13, Standard Specification for Soft or Annealed Copper Wire
3. ASTM B32-08 (2014), Standard Specification for Solder Metal
4. ASTM C1107/C1107M-14a, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
5. ASTM D709-16, Standard Specification for Laminated Thermosetting Materials
6. ASTM E84-16, Standard Test Method for Surface Burning Characteristics of Building Materials

C. Federal Information Processing Standards (FIPS):

1. FIPS PUB 201-2nd Edition (8/1/2013), Personal Identity Verification (PIV) of Federal Employees and Contractors

D. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE Std 100 (2000), The Authoritative Dictionary of IEEE Standards Terms
2. IEEE 81, 2012 Edition (12/2012), Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
3. IEEE 142, 2007 Edition (11/2007), Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book (Color Book Series)
4. IEEE C2 National Electrical Safety Code (NESC), 2017 Edition
5. IEEE C62.41.1, 2002 Edition (11/2002), RN: (12/2008), Guide on Surges Environment in Low Voltage (1000 V and Less) AC Power Circuits

6. IEEE C62.41.2, 2002 Edition (11/2002), CRGD: (12/2012), Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits
- E. International Organization for Standardization (ISO)
 1. ISO 7810, 2003 Edition, A2 (01/2012), Identification Cards – Physical Characteristics
- F. National Electrical Contractors Association (NECA)
 1. NECA 1 2015 Edition (1-2015), Standard for Good Workmanship in Electrical Construction
- G. National Electrical Manufacturers Association (NEMA)
 1. NEMA 250, 2014 Edition (1/2014), Enclosures for Electrical Equipment (1000 Volts Maximum)
 2. NEMA ICS 1 (2000; R 2015), Industrial Control and Systems: General Requirements
 3. NEMA ICS 2 (2000; Errata 3/2008), Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated 600 Volts
 4. NEMA ICS 6 93rd Edition (1993; R 2011), Industrial Control and Systems: Enclosures
- H. National Fire Protection Association (NFPA)
 1. NFPA 70 2017 Edition (2017), National Electrical Code
 2. NFPA 72 2016 Edition (1/2016), National Fire Alarm and Signaling Code.
 3. NFPA 101 2015 Edition (2015), Life Safety Code
 4. NFPA 262 2015 Edition (1/2015), Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
 5. NFPA 730 2014 Edition (1/2014), Guide for Premises Security
 6. NFPA 731 2015 Edition (1/2015), Standard for the Installation of Electronic Premises Security Systems
- I. National Institute of Standards and Technology (NIST)
 1. PIV Card Specifications:
 - a. SP 800-73-2 (9/2008), Interfaces for Personal Identity Verification
 - b. NISTIR 7284 (2006), Personal Identity Verification Card Management Report
 - c. NISTIR 7284 (2006), Personal Identity Verification Card Management Report
 - d. SP 800-76-2 (7/2013), Biometric Data Specification for Personal Identity Verification

- e. SP 800-78-4 (5/2015), Cryptographic Algorithms and Key Sizes for Personal Identity Verification
 - f. SP 800-73-4 (4/2016), PIV Card Application and Middleware Interface Test Guidelines
- 2. PIV Card and Middleware Conformance Testing:
 - a. SP 800-85B (2006), PIV Data Model Conformance Test Guidelines
- 3. PIV Accreditation:
 - a. SP 800-96 (2006), PIV Card / Reader Interoperability Guidelines
- 4. Issuing Organizations:
 - a. SP 800-87 Rev 1 (4/2008), Codes for the Identification of Federal and Federally-Assisted Organizations
 - b. NISTIR 7337 (2006); Personal Identity Verification Demonstration Summary
- J. Security Industry Association (SIA)
 - 1. SIA BIO-01-1993.02 (R2000.06), Biometric Vocabulary Standard
 - 2. SIA DC-01-1988 (R2001.04), DCS Computer Interface (CIS-1) Technical Report
 - 3. SIA DC-03-1990.01 (R2003.10), DCS SIA Format Standard
 - 4. SIA DC-07-2001.04, DCS Computer Interface (CIS-2) Standard
- K. Telecommunications Industries Association (TIA)
 - 1. TIA-232 Rev F (10/1997; R 12/2012), Interface Between Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary data Exchange
 - 2. EIA/ECA-319 Rev E (12/2005), Cabinets, Racks, Panels, and Associated Equipment
 - 3. TIA-455-3, Rev B (7/2009), Procedure to Measure Temperature Cycling Effects on Optical Fibers, Optical Cable, and Other Passive Fiber Optic Components
 - 4. TIA-455, Rev C (8/2014), General Requirements for Standard Test Procedure for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and Other Fiber Optic Components
 - 5. TIA-232 Rev F (10/1997; R 12/2012), Interface Between Data Terminal Equipment and Data Circuit - Terminating Equipment Employing Serial Binary data Exchange
 - 6. TIA-598 Revision D (7/2014), Optical Fiber Cable Color Coding
 - 7. TIA-604-3 Revision B (8/2004; R 1/2014), FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC
 - 8. TIA-604-1 1996 Edition (3/1996; R 1/2012), Fiber Optic Connector Intermateability Standard

L. Underwriters Laboratories (UL)

National Zoological Conservation Biology Institute (NZCBI)
Construct Arabian Leopard Facility (ALF)
Common Work Results for Electronic Security

Phase 2 – Habitat & Animal Bldg
65% Construction Documents
28 0500.10 - 6

1. UL 6 2014 Edition (11/2014), Electrical Rigid Metal Conduit - Steel
2. UL 50 13th Edition (10/2015), Enclosures for Electrical Equipment, Non-Environmental Considerations
3. UL 50E 2nd Edition (10/2015), Enclosures for Electrical Equipment, Environmental Considerations
4. UL 83 15th Edition (3/2014), Thermoplastic-Insulated Wires and Cables
5. UL 294 6th Edition (2/2015), Access Control System Units
6. UL 444 4th Edition (4/2015), Communications Cables
7. UL 464 10th Edition (1/2016), Audible Signaling Devices for Fire Alarm and Signaling Systems, including Accessories
8. UL 467 10th Edition (3/2013), Standard for Safety Grounding and Bonding Equipment
9. UL 497B 4th Edition (12/2012), Protectors for Data Communication and Fire Alarm Circuits
10. UL 609 11th Edition (3/2015), Local Burglar Alarm Units and Systems
11. UL 634 2009 Edition (12/2009; R 3/2015), Connectors and Switches for Use with Burglar-Alarm Systems
12. UL 636 10th Edition (10/2008; R 1/2013), Holdup Alarm Units and Systems
13. UL 639 8th Edition (5/2012), Intrusion Detection Units
14. UL 681 15th Edition (1/2014), Installation and Classification of Burglar and Holdup Alarm Systems
15. UL 796 11th Edition (5/2016), Printed-Wiring Boards
16. UL 797 9th Edition (12/2012), Electrical Metallic Tubing -- Steel
17. UL 827 8th Edition (2/2015), Central Station Alarm Services
18. UL 910 5th Edition (11/1998), Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air
19. UL 969 4th Edition (11/2001), Marking and Labeling Systems
20. UL 972 6th Edition (7/2011), Burglary Resisting Glazing Material
21. UL 1037 6th Edition (9/2016), Antitheft Alarms and Devices
22. UL 1076 5th Edition (3/2015), Proprietary Burglar Alarm Units and Systems
23. UL 1424 4th Edition (1/2015), Power-Limited Fire-Alarm Circuits
24. UL 1492 (3/2002; R 7/2013), Audio-Video Products and Accessories
25. UL 1581 4th Edition (8/2016), Reference Standard for Electrical Wires, Cables, and Flexible Cords
26. UL 1610 4th Edition (7/2016), Central-Station Burglar-Alarm Units
27. UL 1635 3rd Edition (1/2012; R 3/2015), Digital Alarm Communicator System Units
28. UL 1638 5th Edition (1/2016), Visible Signaling Devices for Fire Alarm and Signaling Systems, including Accessories
29. UL 1638A 1st Edition (6/2016), Visual Signaling Appliances for General Signaling Use
30. UL 1655 2nd Edition (11/2014; R 11/2014), Community-Antenna Television Cables
31. UL 1660 5th Edition (7/2014), Liquid-Tight Flexible Nonmetallic Conduit

32. UL 1666 5th Edition (6/2012), Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
33. UL 1981 3rd Edition (4/2015). Central Station Automation Systems
34. UL 2050 5th Edition (11/2010), National Industrial Security Systems
35. UL 2196 1st Edition (3/2012), Tests for Fire Resistive Cables

1.6 DEFINITIONS

- A. ARA: Area of Rescue Assistance.
- B. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
- C. BICSI: Building Industry Consulting Service International.
- D. Controller: An intelligent peripheral control unit that uses a computer for controlling its operation. Where this term is presented with an initial capital letter, this definition applies.
- E. CPU: Central processing unit.
- F. Credential: Data assigned to an entity and used to identify that entity.
- G. DGP: Data Gathering Panel.
- H. EMI: Electromagnetic interference.
- I. EMT: Electric Metallic Tubing.
- J. ESS: Electronic Security System.
- K. GFI: Ground fault interrupter.
- L. Identifier: A credential card, keypad personal identification number or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- M. I/O: Input/Output.
- N. INC: Intelligent Network Controller
- O. Intrusion Zone (IZ): A space or area for which an intrusion must be detected and uniquely identified, the sensor or group of sensors assigned to perform the detection, and any interface equipment between sensors and communication link to central-station control unit.
- P. LAN: Local area network.

- Q. LCD: Liquid-crystal display.
- R. LED: Light-emitting diode.
- S. LOD: Level of Detail.
- T. LOE: Level of Effort.
- U. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- V. M-JPEG: Motion – Joint Photographic Experts Group.
- W. MPEG: Moving picture experts group.
- X. NEC: National Electrical Code.
- Y. NECA: National Electrical Contractors Association.
- Z. NEMA: National Electrical Manufacturers Association.
- AA. NFPA: National Fire Protection Association.
- BB. NRTL: Nationally Recognized Testing Laboratory.
- CC. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- DD. OPS: Office of Protection Services.
- EE. OTDR: Optical Time Domain Reflectometer.
- FF. PACS: Physical Access Control System.
- GG. PIR: Passive infrared.
- HH. PIR Rex: Passive Infrared Request to Exit.
- II. PPSD: Personnel and Physical Security Division (A department within OPS).
- JJ. RCDD: Registered Communications Distribution Designer.
- KK. RF: Radio frequency.
- LL. RFI: Radio-frequency interference.
- MM. RIGID: Rigid conduit is galvanized steel tubing, with a tubing wall that is thick enough to allow it to be threaded.

- NN. RS-232: An TIA/EIA standard for asynchronous serial data communications between terminal devices. This standard defines a 25-pin connector and certain signal characteristics for interfacing computer equipment.
- OO. RS-485: An TIA/EIA standard for multipoint communications.
- PP. SMS: Security Management System – A SMS is a software that incorporates multiple security subsystems (e.g., access control, intrusion detection, closed circuit television, intercom) into a single platform and graphical user interface.
- QQ. Standard Intruder: A person who weighs 100 lb. (45 kg) or more and whose height is 1525 mm (60 in) or more; dressed in standard clothing.
- RR. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
- SS. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- TT. TDMM: Telecommunications Distribution Methods Manual.
- UU. TIA: Telecommunications Industry Association.
- VV. UPS: Uninterruptible Power Supply.
- WW. UTP: Unshielded Twisted Pair.
- XX. VASS: Video Assessment and Surveillance System.
- YY. VPN: Virtual Private Network.
- ZZ. WAN: Wide Area Network.
- AAA. WAV: The digital audio format used in Microsoft Windows.
- BBB. Windows: Operating system by Microsoft Corporation.
- CCC. Workstation: A PC with software that is configured for specific limited security system functions.
- DDD. WYSIWYG: (What You See Is What You Get.) Text and graphics appear on the screen the same as they will print.

1.7 GENERAL ARRANGEMENT OF CONTRACT DOCUMENTS

- A. The Contract Documents supplement to this specification indicates approximate locations of equipment. The installation and/or locations of the equipment and devices shall be

governed by the intent of the design; specification and Contract Documents, with due regard to actual site conditions, recommendations, ambient factors affecting the equipment and operations in the vicinity. The Contract Documents are diagrammatic and do not reveal all offsets, bends, elbows, components, materials, and other specific elements that may be required for proper installation. If any departure from the contract documents is deemed necessary, or in the event of conflicts, the submit details of such departures or conflicts in writing to the owner or owner's representative for his or her comment and/or approval before initiating work.

- B. Anything called for by one of the Contract Documents and not called for by the others shall be of like effect as if required or called by all, except if a provision clearly designed to negate or alter a provision contained in one or more of the other Contract Documents shall have the intended effect. In the event of conflicts among the Contract Documents, the Contract Documents shall take precedence in the following order: the Form of Agreement; the Supplemental General Conditions; the Special Conditions; the Specifications with attachments; and the drawings.

1.8 SUBMITTALS

A. General

1. Comply with the Contract Documents and in accordance with this section. Submittals lacking the breadth or depth of these requirements will be considered incomplete and rejected. Submissions are considered multidisciplinary and require coordination with applicable divisions to provide a complete and comprehensive submission package. Additional general provisions are as follows:
 - a. Schedule submittals to maintain the project schedule. For coordination drawings refer to Division 1 Specification, which outline basic submittal requirements and coordination.
 - b. Identify variations from requirements of Contract Documents and state product and system limitations, which may be detrimental to successful performance of the completed work or system.
 - c. Submit each package at one (1) time for each review and include components from applicable disciplines (e.g., electrical work, architectural finishes, door hardware, etc.) which are required to produce an accurate and detailed depiction of the project.
 - d. Manufacturer's information used for submittal shall have pages with items for approval tagged, items on pages shall be identified, and capacities and performance parameters for review shall be clearly marked through use of an arrow or highlighting. Provide space for COTR and Contractor review stamps.
 - e. Drawings shall be in the project specific version of AutoCAD® or REVIT, drawn accurately, and in accordance with Smithsonian Institution CAD and REVIT Standards. FREEHAND SKETCHES OR COPIED VERSIONS OF

THE CONSTRUCTION DOCUMENTS WILL NOT BE ACCEPTED. If departures from the drawings are subsequently deemed necessary by the Contractor, submit details of such departures and the reasons thereof in writing to the COTR and the PPSD Security Engineer for approval before initiating work.

f. Submittal Format

- 1) Provide one (1) hard-copy of drawings. Make all other submittals as PDF with bookmarks for sections.
- 2) Refer to SI Special Conditions Document for drawing format and content requirements.

B. Pre-Installation Submittal

1. Qualifications

a. Provide Company certifications

- 1) Software House
 - a) Enterprise Partner

b. Include qualifications and manufacturer's certifications for individuals working on the project including but not limited to:

- 1) Software House
 - a) CCURE 800/8000
 - b) CCURE 9000
- 2) American Dynamics
 - a) Victor
 - b) Video Edge
- 3) Cisco
 - a) CCNA
- 4) BICSI
 - a) RCDD

c. Provide project references as outlined in Paragraph 1.11 A "Contractor Qualifications".

2. Product Data

- a. Provide a chart of product data listing the specification section and paragraph number of each product. Annotate if “Provided as Specified” or “Substitution Requested”.
 - b. Product data sheets organized and bookmarked by Specification Division. Annotate deviations from the design documents and the justification for the change.
 - c. Where the words, "or approved equivalent" or like words are used, either furnish the equipment as specified or submit a request for substitution in writing with the make, model, and justification to the COTR and the PPSD Security Engineer for approval.
 - d. If the contractor recommends equipment substitution, the contractor is responsible for complete documentation of the reason for the change including price differential and is financially liable for the design time expended by the security consultant to research the substitution.
3. Shop Drawings
- a. Build upon the design documents to reflect current conditions and approved product data. Annotate deviations from the design documents and the justification for the change.
 - b. Include wiring diagrams to include but not limited to power supplies, card readers, fire alarm connections, elevator interface, and tamper circuits.
 - c. Security door schedule coordinated with Division 8 requirements. Include the following information:
 - 1) Configuration Number
 - 2) Door Number (Derived from Architectural Drawings)
 - 3) Floor Plan Sheet Number
 - 4) Standard Detail Number
 - 5) Door Description (Derived from Loading Sheets)
 - 6) Security Point Number (Derived from Loading Sheets)
 - 7) Door Position or Monitoring Device Type, Make & Model Number
 - 8) Lock Type, Model Number & Power Input/Draw (standby/active)
 - 9) Card Reader Type, Make & Model Number
 - 10) Shunting Device Type, Make & Model Number
 - 11) Sounder Type, Make & Model Number
 - 12) Camera Make & Model Number
 - 13) Misc. devices as required
 - a) Delayed Egress Type, Make & Model Number
 - b) Intercom Make & Model Number
 - c) Electric Transfer Hinge
 - d) Electric Pass-through device
 - 14) Remarks column indicating special notes or door configurations

C. Pre-Programming Submittal

1. IP Addressing Scheme

- a. Provide OPS with the quantity of devices requiring IP addresses. OPS will then provide the IP addressing scheme.

2. Loading Sheets

- a. Provide loading sheets for each DGP, including input and output boards for all field panels associated with the project.
- b. OPS-PPSD will provide blank electronic sheets for contractor use.
- c. Provide a spreadsheet for each DGP. Name the spreadsheet with the DGP number (e.g. "Site Name DGP-01.xls")

D. Pre-Acceptance Testing

1. OPS-PPSD will provide blank testing forms for contractor to reproduce and fill out during testing.

2. Contractor Field Test

- a. Contractor performs the Contractor Field Test (CFT) of all devices utilizing OPS provided forms and submits test results to OPS-PPSD.

3. Performance Verification Test

- a. Based on the OPS-PPSD approval of the Contractor's Field Test, the COTR will schedule the PVT with the Contractor and OPS-PPSD.
- b. OPS-PPSD will witness the Contractor conduct the PVT of all devices utilizing the same form as for the CFT.

E. Closeout Submittals

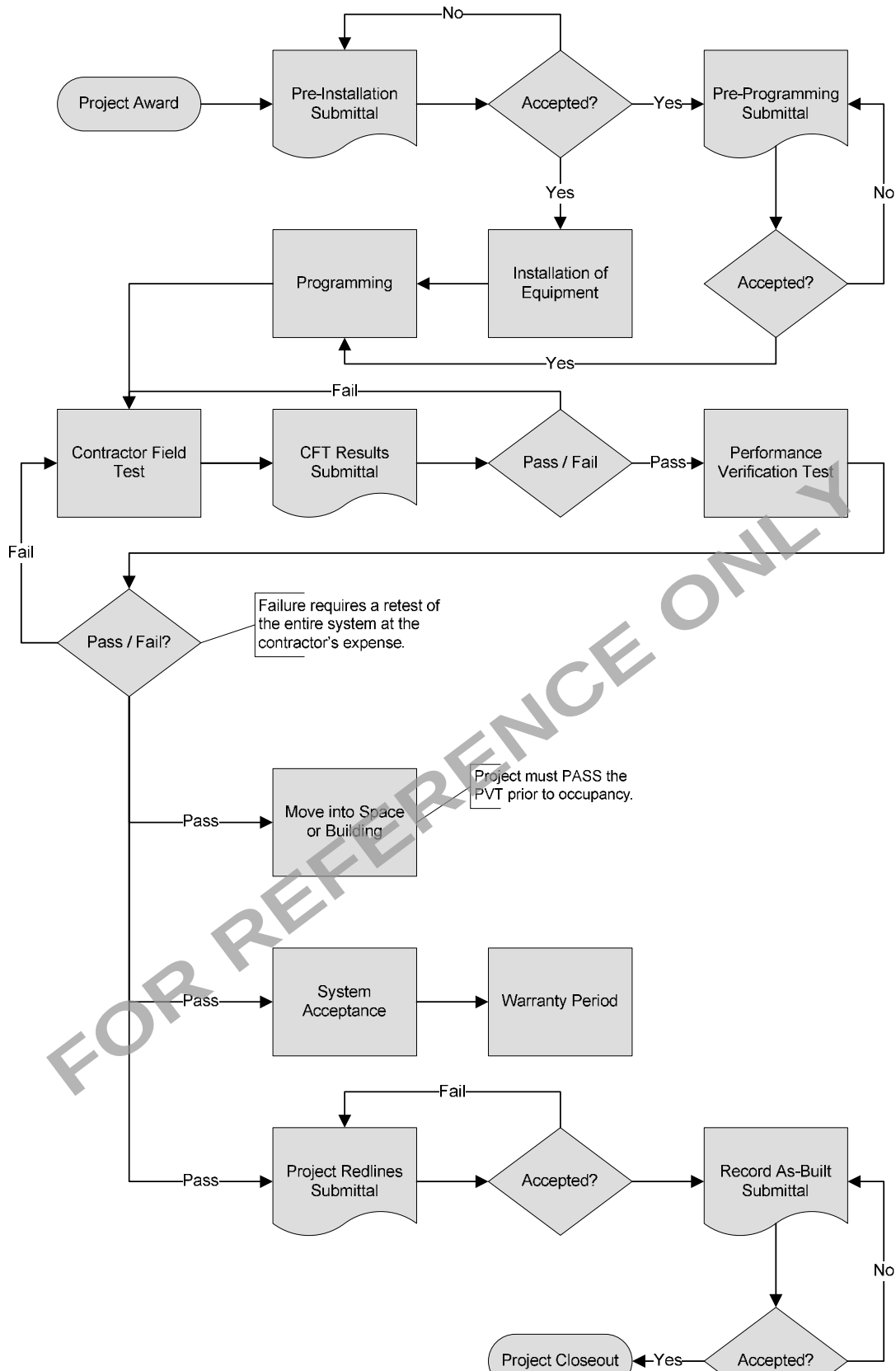
1. Project Redlines

- a. Neatly maintain an up-to-date set of construction redlines detailing current location and configuration of the project components.
- b. Mark the redline documents with the words 'Master Redlines' on the cover sheet and be maintained by the Contractor in the project office.
- c. Field drawings shall be used for data gathering & field changes. These changes shall be made to the master redline documents daily. Field drawings shall not be considered "master redlines".
- d. Provide access to redline documents anytime during the project for review and inspection by the COTR or authorized OPS representative.
- e. Any project component or assembly that is not installed in strict accordance with the drawings shall be so noted on the drawings.

- f. Submit the Master Redline document to the COTR and PPSD Security Engineer for review and approval of all changes or modifications to the documents prior to producing Record Construction Documents. The COTR shall be given a minimum of a thirty (30) day review period to determine the adequacy of the Master Redlines. If the master redlines are found suitable by the COTR and the PPSD Security Engineer, the COTR will initial and date each sheet and turn the redlines over to the Contractor for Record As-Built development.
2. Record Construction Documents (Record As-Built)
 - a. The submitted as built documents shall be in editable electronic formats and the ownership of the drawings shall be fully relinquished to the owner.

1.9 PROJECT PROCESS DIAGRAM

- A. The ESS Project Process Diagram (below) is provided to identify key consecutive or concurrent tasks and milestones required to ensure the project is completed prior to owner occupancy. Substantial completion means all systems have been fully tested and accepted in writing by OPS. Minor or non-life safety related punch list items may continue through owner occupancy, but shall be resolved within two (2) weeks of official date of occupancy.
- B. The contractor is encouraged to utilize the diagram for the development of project schedules, and coordinating submissions.



1.10 COORDINATION

- A. Coordinate arrangement, mounting, and support of electronic security equipment:
- B. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
- C. To provide for ease of disconnecting the equipment with minimum interference to other installations.
- D. To allow right of way for piping and conduit installed at required heights.
- E. Ensure raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- F. Coordinate the installation of required supporting discipline devices placement and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- G. Coordinate the locations of access panels and doors for electronic security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- H. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.11 QUALITY ASSURANCE

- A. Contractor Qualifications
 - 1. The Contractor or security sub-contractor shall be a licensed security Contractor with a minimum of five (5) years' experience installing and servicing systems of similar scope and complexity. The Contractor shall be an authorized regional representative of the electronic security systems included in the project scope.
 - 2. Provide four (4) current references from clients with systems of similar scope and complexity which became operational in the past three (3) years. At least three (3) of the references shall be utilizing the same system components, in a similar configuration as the proposed system. The references must include a current point of contact, company or agency name, address, telephone number, complete system description, date of completion, and approximate cost of the project.
 - 3. The owner reserves the option to visit the reference sites, with the site owner's permission and representative, to verify the quality of installation and the references' level of satisfaction with the system.
 - 4. Provide copies of system manufacturer certification for all technicians. Only utilize factory-trained technicians to install, program, and service the electronic security

systems. The Lead Technician shall have a minimum of five (5) continuous years of technical experience in electronic security systems.

5. The Contractor shall have a local service facility located within 60 miles of the project site. The local facility shall include sufficient spare parts inventory to support the service requirements associated with this contract. The COTR and the PPSD Security Engineer reserves the option of visiting the company's facility to verify the service inventory and presence of a local service organization.
6. Refer to Division 27 Specifications for additional requirements for cabling.

B. Electrical Components, Devices, and Accessories

1. Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Material & Workmanship

1. Unless otherwise specifically provided under this contract, all equipment, material and articles to be incorporated in the work shall be new and of the most suitable grade for the purposes intended.
2. References to any equipment, material, article or patented process, by trade name, make or catalog number shall be regarded as establishing a standard of performance and quality, and shall not be construed as limiting competition.
3. When so directed, the Contractor shall submit samples for approval at the Contractor's expense. Equipment, materials, and articles installed or used without the required approval shall be at the Contractor's risk of rejection.
4. Warranties of all work and installed products shall be according to the Contract General Provisions.

1.12 MAINTENANCE & SERVICE

A. General Requirements

1. Provide services required and equipment necessary to maintain the electronic security system in an operational state as specified for a period of one (1) year after formal written acceptance of the system.
2. Provide necessary material required for performing scheduled adjustments or other non-scheduled work. Minimize impacts on facility operations when performing scheduled adjustments or other non-scheduled work. See also General Project Requirements.

B. Description of Work

1. The adjustment and repair of the security system includes the following items: computers, equipment, communications transmission equipment and data transmission media (DTM), local processors, security system sensors, access control equipment, facility interface, signal transmission equipment, intercoms, and video equipment.

C. Personnel:

1. Service personnel shall be certified in the maintenance and repair of the selected type of equipment and qualified to accomplish all work promptly and satisfactorily. Advise the COTR and the PPSD Security Engineer in writing of the name of the designated service representative, and of any change in personnel. Provide the COTR and the PPSD Security Engineer with copies of system manufacturer certification for the designated service representative.

D. Emergency Service

1. The owner shall initiate service calls whenever the system is not functioning properly. Provide the owner with an emergency service center telephone number. Staff the emergency service center 24 hours a day 365 days a year.
2. The Smithsonian Institution has sole authority for determining catastrophic and non-catastrophic system failures.
3. Catastrophic system failures are defined as any system failure that the Owner determines will place the facility(s) at increased risk. For catastrophic system failures, provide same day four (4) hour service response with a defect correction time not to exceed eight (8) hours from notification.
4. For non-catastrophic failures, provide eight (8) hour service response with a defect correction time not to exceed 24 hours from notification.

E. Work Request

1. Separately record each service call request, as received. The record shall include the serial number identifying the component involved, its location, date and time the call was received, specific nature of trouble, names of service personnel assigned to the task, instructions describing the action taken, the amount and nature of the materials used, and the date and time of commencement and completion. Deliver a record of the work performed within five (5) working days after the work was completed.

F. System Modifications

1. Make any recommendations for system modification in writing to the COTR and the PPSD Security Engineer. No system modifications, including operating parameters and control settings, shall be made without prior written approval from the COTR and the PPSD Security Engineer.

1.13 PROJECT ENVIRONMENTAL CONDITIONS

A. Control Station

1. Rated for continuous operation in ambient conditions of 60 to 85 deg F (16 to 30 deg C) and a relative humidity of 20 to 80 percent, non-condensing.

B. Interior, Controlled Environment

1. System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 1 enclosure.

C. Interior, Uncontrolled Environment

1. System components installed in non-temperature-controlled interior environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F (-18 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, non-condensing. NEMA 250, Type 4x enclosures.

D. Exterior Environment

1. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of -30 to 122 deg F (-34 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 137 km/h (85 mph) and snow cover up to 24 in (610 mm) thick. NEMA 250, Type 4X enclosures.

E. Hazardous Environment

1. System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.

F. Corrosive Environment

1. For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

G. Security Environment

1. Use vandal resistant enclosures in high-risk areas where equipment may be subject to damage.

1.14 EQUIPMENT AND MATERIALS

A. General Equipment Requirements

1. Equipment and materials shall be standard, current products of the manufacturer, and be suitable for the systems being installed and the intent of the design.
2. Plastic laminated nameplates shall be installed on all components accessed by - Smithsonian Institution Security Maintenance Personnel. Each nameplate shall identify the component and its location within the security system. The laminated plastic shall be 0.06 in (1.6 mm) thick, black with white lettering center core. Nameplates shall be a minimum of 0.75 in (19 mm) high, with a minimum of 0.13 in (3.3 mm) high-engraved block lettering. Nameplates are to be attached to the component with screws or located as required by security documentation plans and specifications. All console monitors shall be labeled with the monitor number and intended function. Submit planned naming conventions for approval.
3. Any material, device, or equipment damages including dents and marred finishes before or during installation and before acceptance of the completed system, shall be replaced unless repairs can be made that are acceptable to the COTR and the PPSD Security Engineer. Any such replacement or repairs, including repairs to the finish, shall be made at no cost to the Owner.
4. Parts of the project site are finished spaces, including paint, trim, wall covering, floor treatments, lighting, and building mechanical systems. Therefore, perform the work specified herein, such that, at the completion of his work, all finished space is restored to the original condition existing prior to the commencement of work. During the course of performing the work specified herein, if the Contractor encounters any damaged finish in any area where the Contractor's work is to be performed, notify the COTR in writing prior to performing work in that area. Proceed with the work in these areas only after receiving written confirmation that the existing conditions have been documented and authorization has been given to proceed.

1.15 COMPONENT ENCLOSURES

A. Tamper Provisions and Tamper Switches

1. Enclosures with terminal strips or circuit boards require tamper switches.
2. Arrange tamper switches to initiate an alarm signal that will report to the monitoring station when the door or cover is moved.
3. Tamper switches shall be inaccessible until the switch is activated. Be connected to circuits which are under electrical supervision at all times, irrespective of the protection mode in which the circuit is operating. Be spring-loaded and held in the closed position by the door or cover and be wired so they break the circuit when the door cover is disturbed. Tamper circuits shall be adjustable type screw sets and shall be adjusted by the contractor to eliminate nuisance alarms associated with incorrectly mounted tamper device shall annunciate prior to the enclosure door opening (within 1/4 " tolerance).
4. The single gang junction boxes for the portrait alarming and pull boxes with less than 102 square mm will not require tamper switches.
5. All enclosures over 12 sq in (305 sq mm) shall be hinged with an enclosure lock.
6. Control Enclosures: Maintenance/Safety switches on control enclosures, which must be opened to make routing maintenance adjustments to the system and to service the power supplies, shall be push/pull-set automatic reset type.
7. Provide one (1) enclosure tamper switch for each 24 in (609 mm) of enclosure lock side opening evenly spaced.
8. All security screws shall be Torx-Post Security Screws.

1.16 WARRANTY

- A. The Contractor shall, as a condition precedent to the final payment, execute a written guarantee (warranty) to the COTR certifying all contract requirements have been completed according to the final specifications. Contract drawings and the warranty of all materials and equipment furnished under this contract are to remain in satisfactory operating condition (ordinary wear and tear, abuse and causes beyond his control for this work accepted) for one (1) year from the date the Contractor received written notification of final acceptance from the COTR and the PPSD Security Engineer. Repair or replace all defects or damages due to faulty materials or workmanship without delay, to the COTR's satisfaction, and at the Contractor's expense.
- B. When equipment and labor covered by the Contractor's warranty, or by a manufacturer's warranty, have been replaced or restored because of its failure during the warranty period, the warranty period for the replaced or repaired equipment or restored work shall be reinstated for a period equal to the original warranty period, and commencing with the date of completion of the replacement or restoration work. In the event any manufacturer customarily provides a warranty period greater than one (1) year, the Contractor's warranty shall be for the same duration for that component.

PART 2 - PRODUCTS

2.1 THERE ARE NO PRODUCTS IN THIS SPECIFICATION

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SECURITY INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 GENERAL

- A. Install all system components and appurtenances in accordance with the manufacturer's instructions, ANSI C2, and furnish all necessary interconnections, services, and adjustments required for a complete and operable system as specified. Control signals, communications, and data transmission lines grounding shall be installed as necessary to preclude ground loops, noise, and surges from affecting system operation. Equipment, materials, installation, workmanship, inspection, and testing shall be in accordance with manufacturers' recommendations and as modified herein.
- B. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the Riser/Connection diagram for all schematic system installation/termination/wiring data.
- C. Firmly attach equipment to walls and ceiling/floor assemblies (e.g., sensors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

- D. Current Site Conditions: Visit the site and verify site conditions are in agreement with the design package. Report all changes to the site or conditions that will affect performance of the system to the COTR as part of the Pre-Installation Submittal. Take no corrective action without written permission from the COTR.

3.3 SYSTEM PROGRAMMING

A. General

1. The following Loading Sheet submittals are required:
 - a. Shop Drawings – Pre-Installation Submittal
 - b. Final Construction Document Submittal – Closeout Submittal
2. Loading Sheets
 - a. See the attached loading sheets. Refer to Section 1 regarding loading sheet submissions.
 - b. System Configuration and Data Entry:
 - 1) The contractor is responsible for providing all system configuration and data entry for the SMS and subsystems (e.g., intercom, Inovonics wireless, digital video recorders, network video recorders). All data entry shall be performed to Smithsonian Institution's standards & guidelines. The Contractor is responsible for participating in all meetings with the OPS and the client to compile the information needed for data entry. These meetings shall be established at the beginning of the project and incorporated in to the project schedule as a milestone task. The contractor shall be responsible for all data collection, data entry, and system configuration. The contractor shall collect, enter, & program and/or configure the following components:
 - a) Access control system components
 - b) All intrusion detection system components
 - c) Video surveillance, control and recording systems
 - d) Intercom systems components
 - e) All other security subsystems shown in the contract documents

3. Graphics

- a. Based on as-built drawings developed for the construction project, create all map sets and system icons showing locations of all alarms and field devices.
- b. Produce graphical maps of all alarm points installed under this contract including perimeter and exterior alarm points.
- c. Create and install all graphics needed to make the system operational.
- d. Utilize data from the contract documents, Contractor's field surveys, and all other pertinent information in the Contractor's possession to complete the graphics.
- e. Identify and request from the COTR and the PPSD Security Engineer, any additional data needed to provide a complete graphics package.
- f. Graphics shall have sufficient level of detail for the system operator to assess the alarm.
- g. Supply hard copy, color examples at least 8 x 10 in (203.2 x 254 mm) of each type of graphic to be used for the completed Security system. Deliver the graphics examples to the COTR and the PPSD Security Engineer for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires them.

B. Alarm / Event Identification Format for Monitoring Station

1. Initial Descriptor

- a. The Initial Descriptor is a brief description of the event taking place and shall be no more than 50 characters in length. Contact OPS-PPSD for any Building ID, Area ID or Device / Condition Type not listed below.
- b. Building ID
 - 1) This is a two (2) or four (4) character identification of the building where the event is taking place. This shall follow the standard format as shown in the listing below. Confirm buildings and identifications with the owner.

Building	ID
African Art	AA
Air and Space	AS
American History	AH
American Indian (NY)	IN
American Indian Mall	IM
Anacostia	AN
Ancon (STRI)	AC
Apollo Drive	AD
Arts and Industries	AB
Barro Colorado (STRI)	BC

Building	ID
Hirshhorn	HH
Horticulture Greenhouse	HG
Library (STRI)	LB
Maintenance Shop (STRI)	TP
MSC (Suitland)	MS
NAOS (STRI)	NAOS
National Zoological Park	NZ
Natural History	NH
NMAAHC	AAHC
Patent Office Building	PB

Building	ID	Building	ID
Bocas del Toro (STRI)	BT	Pennsy Drive	SISC
Capital Gallery	CG	Postal Museum	PM
Columbia Warehouse	CW	Quad	SQ
Conference Center (STRI)	CC	Renwick	RW
Cooper Hewitt (NY)	CH	Research Branch (NY)	RB
CRC (Suitland)	CR	Sackler	SK
Culebra (STRI)	CU	SAO Arizona	AZ
Dulles	DL	SAO Hilo HI	HI
Engineering Building (STRI)	EB	SAO Mauna Kea HI	MK
Folk Life Festival	FF	SCBI Front Royal VA	FZ
Freer	FR	SERC	SR
Galeta (STRI)	GA	SI Castle	SB
Gamboa (STRI)	GM	Tivoli Facility (STRI)	TV
Garber (Suitland)	GB	Tupper Facility (STRI)	TP
Herndon	HN	Victor Building	VB

c. Monitor Point Location

- 1) This is the monitor point physical location. There is no separation between the Building ID and the Monitor Point Location.
- 2) Description of iStar:
 - a) The Monitoring Point Location includes a two (2) character descriptor for the iStar Cluster, followed by a colon and then a two (2) character descriptor for the iStar panel followed by a colon then a one (1) character space.
 - b) Next is the one (1) character descriptor for ACM # (1 or 2) 'ACM: #' followed by a one (1) character space.
 - c) Next is the device connection location for where the device terminates using 'I8' for an I-8 module, 'R8' for an R-8 module, 'RDR' for a reader module, followed by a colon. Then a one (1) character number representing which module it is (i.e. the fourth I-8 module), followed by a colon. Last is a one (1) character number representing the input number on the module; the inputs on the ACM board require a two (2) character number.

3) Example of iStar

- a) xx01:01 ACM:1:i06 = iStar Cluster 01, iStar #01, ACM #1, main panel, sixth input
- b) xx01:02 ACM:2 I8:3:i6 = iStar Cluster 01, iStar #02, ACM#2, I-8 module #3, sixth input
- c) xx02:16 ACM:1 R8:2:o4 = iStar Cluster 02, iStar #16, ACM #1, R-8 module #2, fourth output
- d) xx01:15 ACM:1 RDR:4:i2 = iStar Cluster 01, iStar #15, ACM#1, reader module #4, second input

d. Area ID (Type)

- 1) This is a brief description of the location of the alarm / event. There shall be a one (1) character space between the Monitor Point Location and the Area ID. At a minimum level of description, this shall follow the standard format as shown in the listing below. Confirm areas and identifications with the owner.

Description	Area ID
Vault	VAULT
Collection Storage	COLL STORAGE
Archive Areas	ARCHIVE
Collection Archive Areas	COLL ARCHIVE
Collection Processing / Preparation Areas	COLL PREP ROOM
Alcohol Storage Areas	ALCOHOL
Cold Collection Storage Areas	COLD STORAGE
Curatorial Areas	CURATORIAL
Exhibit Gallery (XX To be replaced with Gallery No.)	GALLERY XX
Exhibit Alarms Located in Lobbies or Reception Areas	LOBBY EXHIBIT
Exhibit or Artifact Alarms in "Other" Registrar Areas	MISC EXHIBIT
Registrar Areas	REGISTRAR
Perimeter Door, Glass Break, Motion	PERIMETER
Staff Cafeteria	STAFF CAFE
Public Access Cafeteria	PUBLIC CAFE
Public Staff Separation Door	STAFF DOOR
Museum Shop	MUSEUM SHOP
Museum Shop Storage Areas	MUSEUM SHOP
Cash Processing Areas	CASH ROOM
Automated Teller Machines	ATM
Executive Office Space	EXECUTIVE

Description	Area ID
Support Staff Office Space	STAFF OFFICE
Loading Dock Areas	LOADING DOCK
Security Unit Control Room	UNIT CONTROL
Security Wire Closet	WIRE CLOSET
Computer Center Rooms	COMPUTER
Mechanical Room	MECHANICAL
Electrical Room	ELECTRICAL
Communication Closet	COMM CLOSET
Fabrication Shop	FABRICATION
Support Staff Storage Area	STAFF STORAGE
Warehouse Storage Area	WAREHOUSE
Shipping and Receiving Area	SHIPPING
Security Officer Kiosks / Posts	SECURITY POST
Information Booths	INFO BOOTH
Locker Rooms	LOCKER ROOM
Laboratories	LABORATORIES
Libraries	LIBRARY
Liquor Storage Areas	LIQUOR
Child Care Centers	CHILD CARE
Photo Processing Laboratories	PHOTO LAB
Animal Area for Public Viewing	ANIMAL
Animal Area not for Public Viewing	ANIMAL OFF-
Outside Animal Area	ANIMAL YARD
Marine Animal Area	ANIMAL TANK
Animal/Keeper Area	KEEPER
Keeper (only) Area	KEEPER SPACE

e. Device / Condition Type

- 1) This is a two (2) digit descriptor for the type of device / condition that initiated the alarm / event. There is a one (1) character space between the Area ID and the Device / Condition Type. This follows the standard format as shown in the listing below. Confirm device / condition identifications with the owner.

Type of Device / Condition	ID
Door Contact	DC
Motion Detector	MD
Vibration Detector	VD
Glass Break Detector	GB

Type of Device / Condition	ID
Window Contact	WC
Hazard Alarm	HZ
Case / Display Alarm	CA
Low / Missing Battery	LB

Type of Device / Condition	ID	Type of Device / Condition	ID
Hold Up / Duress Button	HU	Communication Failure	CF
Bill Trap (Last Bill Detector)	BT	Security Fault	SF
Door Held Open	HO	UPS / Power Supply Trouble	PT
Door Forced Open	FO	Restore / Reset	RS
Power Failure	PF	Proximity Alarm	PA
Tamper Alarm	TP	Pressure Mat	PM
Delayed Egress Pre Alarm	DE	HVAC Duct Alarm	DA
Temperature Alarm	TA	Lock Secure	LS
Shock Sensor	SS	Battery Fail	BF
Photo Beam	PB	Tamper Alarm	TP
Request to Exit	REX	Lock	LK
Seismic Alarm	SA	Door Status Monitor	DS
Video Loss	VL		M
Supervision Error	SE	Sounder	SD

f. Examples for the Initial Descriptor:

- 1) National Museum of Natural History monitor point location DGP chain 1 DGP number 2 first I-8 input 4, collection storage motion detector in alarm.
 - a) NH01:02 I8:1:i4 COLL STORAGE MD
- 2) Arts and Industries Building monitor point location DGP chain 3 DGP number 4 main panel input 6, public staff separation door contact.
 - a) AB03:04 M:i6 STAFF DOOR DC

2. Secondary Descriptor

- a. The Secondary Descriptor is 128 characters
- b. This is an in-depth description for the location of the alarm / event taking place. If multiple devices are connected to the same monitor point the number of devices should be indicated.
- c. Examples for the secondary descriptor
 - 1) National Museum of Natural History monitor point location DGP chain 1, DGP number 6, I32 board input 31, collection storage motion detector in alarm.

- a) NH01:06 I32:i31 COLL STORAGE MD: NMNH 5th Fl East Wing Rm. 5210 Motion Detectors (3).
- 2) Arts and Industries Building monitor point location DGP chain 1, DGP number 2 third I-8 board input 5, public staff separation door forced open.
- a) AB01:02 I8:3:i5 STAFF DOOR FO: AIB 1st Fl East Hall Card Access Door Forced Open.

d. Linked Instruction Event

- 1) This is a full instructional description for the processing of the alarm / event and follows the standard format of:
 - a) Repeat 50 character descriptor
 - b) In-depth description of location
 - c) Response instructions
 - d) Logging instructions
 - e) Reset instructions
 - f) Nearest camera location (If multiple views are available list all)
 - g) DGP input is connected to

e. Examples for the linked instructional event

- 1) National Museum of Natural History monitor point location DGP chain 1 DGP number 3, I32 board input 31, collection storage motion detector in alarm.

Step	Display
1	NH01:03 I32:i31 COLL STORAGE MD
2	5th fl east wing Rm. 5210 motion detectors (3)
3	Dispatch officer to investigate and report findings
4	Log officer's name and actions into computer log
5	Device resets automatically when motion has stopped
6	Nearest camera is No. (camera Nos. provides other
7	Device connected to DGP

C. Alarm / Event Mapping Requirements

1. General

- a. All maps associated with alarm / event call-ups shall be a black foreground on a white background.

2. Map Information Screen

- a. The map information screen shall provide access to three different map levels for each event
- b. Building Floor Map
 - 1) This map has the quadrant where the event is taking place line colored blue or the colored event icon in place. Identify this map with the building name and floor at the bottom of the map.
- c. Quadrant Map
 - 1) This is the map called up by the system automatically upon event activation. Identify this map with the building name, floor number, and quadrant at the bottom of the map. This map has the icon representing the event shown upon call up. Clicking on the icon or a map “zoom in” icon at this map level calls up the Area map.
- d. Area Map
 - 1) This map represents the local area of the building where the event is taking place. This map contains all icons associated with this area. These icons are “living”, changing colors as the associated devices change state. Identify this map with the building name, floor number, quadrant, and area name at the bottom of the map.

3. Mapping icons

- a. Mapping icons are “living” changing color as the associated devices change state.
 - 1) Red = alarm / activated state
 - 2) Green = secure / normal state
 - 3) Yellow = masked, shunted, accessed, etc. state
- b. Group and position mapping icons represented on the Area map as follows:
 - 1) Motion detectors providing back up to perimeter door(s) / window(s).
 - a) Place a single icon in a close geographical position to the protected door(s) or window(s), to represent all devices in the zone or group
 - 2) Motion detectors providing back up to public staff separation doors and other internal doors.

- a) Place a single icon in a close geographical position to the protected door.
- 3) Motion detectors providing volumetric protection of a room.
 - a) Place a single icon in the center of the room, to represent all devices in the zone or group
- 4) Glass break detectors protecting perimeter windows
 - a) Place a single icon in a close geographical position to the center of the window or group of windows, to represent all devices in the zone or group
- 5) Door contacts protecting individual perimeter doors or logical groups of perimeter doors.
 - a) Place a single icon in a close geographical position to the center of the door or group of doors, to represent all devices in the zone or group
- 6) Delayed egress pre alarm contacts protecting individual doors or logical groups of doors.
 - a) Place a single icon in a close geographical position to the center of the door or group of doors, to represent all devices in the zone or group.
- 7) Window contacts protecting individual perimeter windows or logical groups of perimeter windows.
 - a) Place a single icon in a close geographical position to the center of the window or group of windows, to represent all devices in the zone or group.

- 8) Card reader events to include door forced open and door held open alarms.
 - a) A single icon shall be the same as the door contact protecting the door.
 - b) Icon descriptor shall identify the appropriate event taking place.
- 9) Tamper alarms protecting panels in security closets.
 - a) Place a single icon in the center of the room, to represent all devices in the zone or group.
- 10) Tamper alarms protecting individual devices or logical groups of devices.
 - a) Place a single icon in close geographical position to the device or group of devices, to represent all devices in the zone or group.
- 11) Exhibit level case/display alarms.
 - a) A single icon shall represent all devices protecting the case/display.
 - b) Place icon directly over the case/display so the case outline is still visible below (around) the icon
 - c) Icon descriptor shall identify the appropriate device in alarm.
- 12) Vibration detectors protecting any physical barrier or point of entry.
 - a) Place a single icon in close geographical position to the physical barrier / point of entry or group of devices, to represent all devices in the zone or group.

D. System Programming

1. General Programming Requirements

- a. Use the following section to identify the anticipated level of effort (LoE) required setup, program, and configuring the ESS.
- b. Provide all setup, configuration, and programming to include data entry for the SMS and subsystems (e.g., video system, intercoms, digital video recorders, intrusion devices, maps and icons, time synchronization, including integration of subsystems to the SMS.

2. Configuration Management of Servers

- a. Provide SI-OPS the security system servers for baseline configuration 90 days before system programming begins.
 - b. Once the security system server is baselined according to SI-OCIO requirements the server will be returned to the security contractor for system programming.
 - c. There are other programming requirements the contractor needs assistance on as follows:
 - 1) OPS has to enter the Levels and Permissions of programming
 - 2) Synchronize system with C-Cure Central
 - 3) Employee card reader data will be automatically entered in the system server
 - 4) OPS will enter Card reader Clearances
3. Level of Effort for Programming
- a. Perform and complete system programming (including all data entry) at an offsite location using the Contractor's own copy of the C*Cure 800/8000 software which must be the same version SI is using.
 - b. Deliver the completed forms (loading sheets) to the COTR and PPSD Security Engineer for review and approval at least 90 calendar days prior to the scheduled date the Contractor requires it.
 - c. Once system programming has been completed, deliver the programmin to the COTR and the PPSD Security engineer on data entry forms (loading sheets) and an approved electronic medium.
 - d. System programming may not be uploaded until the COTR and the PPSD security Engineer provide written approval.
 - e. The Contractor is responsible for backing up the system prior to uploading new programming data.
 - f. Additional programming requirements are provided as follows.
 - 1) Programming for New SMS Server
 - a) Provide all other system related programming.
 - b) Upload personnel information (e.g., ID Cards backgrounds, names, access privileges, personnel photos, access schedules, personnel groupings)
 - c) Coordinate with OPS for device configurations, standards, and groupings. SI shall provide database to support Contractor's data entry tasks.
 - d) Conduct a weekly coordination meeting and work alongside OPS to ensure data uploading is performed without incident of loss of function or data loss.
 - 2) Programming for Existing SMS Servers

- a) Perform all related system programming except for personnel data as noted.
 - b) The contractor is not responsible for uploading personnel information (e.g., ID Cards backgrounds, names, access privileges, access schedules, personnel groupings).
 - c) Conduct a weekly coordination meeting and work alongside OPS to ensure data uploading is performed without incident of loss of function or data loss.
 - d) Perform system programming for SMS servers using the Contractor's own server and software. These servers shall not be connected to existing devices or systems at any time.
- g. Identify any additional data needed to provide a complete and operational system as described in the contract documents and request the information from the COTR and the PPSD Security Engineer.
- h. Programming effort requires a high level of coordination between Contractor and OPS to ensure programming is performed in accordance with SI requirements and programming uploads do not disrupt existing systems functionality.
- 1) Conduct a weekly coordination meeting and work alongside OPS to ensure data uploading is performed without incident of loss of function or data loss.
- i. Ensure data uploading is performed without incident or loss of function or data loss.
- j. The following Level of Effort Chart is provided to communicate the expected level of effort required by contractors on SI ESS projects. Determine actual levels of effort prior to bidding on the project.

SMS Setup & Configuration

Description of Tasks	Develop System Loading Sheets	e.g., program monitoring stations, programming networks, interconnections between CCTV, intercoms, time synchronization
	Coordination	e.g., retrieve IP addresses, naming conventions, standard event descriptions, programming templates, coordinate special system needs
	Initial Set-up Configuration	e.g., Load system Operating System and Application software, general system configurations
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	e.g., program monitoring stations, programming networks, interconnections between CCTV, intercoms, time synchronization
	Final Checks	e.g., check all system diagnostics (e.g., clients, panels)
	Level of Effort (Typical Tasks)	Load and set-up 4-6 CDs and configure servers (to configure Loading and Configuring software Administrative account, audit log Keystrokes, mouse clicks, multi-screen configuration

Electronic Entry Control Systems

Description of Tasks	Develop System Loading Sheets	e.g., setup of device, door groups & schedules, REX, Locks, link graphics
	Coordination	e.g., confirming device configurations, naming conventions, event description and narratives
	Initial Set-up Configuration	e.g., enter data from loading sheets; configure components, link events, cameras, and graphics
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	e.g., setup of device, door groups & schedules, REX, Locks, link graphics
	Final Checks	e.g., performing entry testing to confirm correct set-up and configuration
	Level of Effort (Typical Tasks)	e.g., creating a door, door configuration, adding request to exit, door monitors and relays, door timers, door related events (e.g., access, access denied, forced open, held open), linkages, controlled areas, advanced door monitoring, time zones, sequence of operations

Intrusion Detection Systems

Description of Tasks	Develop System Loading Sheets	e.g., enter door groups & schedules, link devices - REX, lock, & graphics
	Coordination	e.g., confirming device configurations, naming conventions, event description and narratives
	Initial Set-up Configuration	e.g., enter data from loading sheets; configure components, link events, cameras, and graphics
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	e.g., enter door groups & schedules, link devices - REX, lock, & graphics
	Final Checks	e.g., walk test, device position, and masking
	Level of Effort (Typical Tasks)	e.g., setting up monitoring and control points (e.g., motion sensors, glass breaks, vibration sensor, strobes, sounders) creating intrusion zones, creating arm/disarm panel, timed sequences, time zones, icon placements on graphic maps, clearance levels, events (e.g., armed, disarmed, zone violation, device alarm activations), LCD reader messages,

CCTV Systems

Description of Tasks	Develop System Loading Sheets	e.g., programming call-ups recording
	Coordination	e.g., confirming device configurations, naming conventions
	Initial Set-up Configuration	e.g., enter data from loading sheets; camera naming convention, sequences, configure components)
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	e.g., programming call-ups recording
	Final Checks	e.g., confirm area of coverage, call-up per event generated and recording rates
	Level of Effort (Typical Tasks)	e.g., setting up cameras points, recording ratios (e.g., normal, alarm event) timed recording, linkages, maps placements, call-ups

Intercoms Systems

Description of Tasks	Develop System Loading Sheets	e.g., programming events & call-ups
	Coordination	e.g., confirming device configurations, naming conventions, event description and narratives
	Initial Set-up Configuration	e.g., enter data from loading sheets; configure components, link events, cameras, and graphics
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	e.g., programming events & call-ups
	Final Checks	e.g., confirm operation, SMS event generation and camera call-up
	Level of Effort (Typical Tasks)	e.g., setup linkages, events for activations, device troubles, land devices on graphic maps

Console Monitoring**Components**

Description of Tasks	Develop System Loading Sheets	N/A
	Coordination	per monitor
	Initial Set-up Configuration	per monitor
	Graphic Maps	e.g., develop naming conventions, develop file folders, confirming accuracy of AutoCAD Floor Plans, convert file into jpeg file then to bitmap.bmp file
	System Programming	N/A
	Final Checks	per monitor
	Level of Effort (Typical Tasks)	N/A

Note: Programming tasks are supported through the contractor's development of the Submittals.

END OF SECTION 280500.10

SECTION 28 0507.10 - POWER SOURCES FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. The power sources support the electronic security systems (ESS).
- B. Electrical Power
 - 1. Provide an automatic transfer switch for switching between primary and generator power.
- C. Uninterruptible Power Supply (UPS)
 - 1. The switch from primary power to generator shall generate an AC Fail alarm on the Physical Access Control System (PACS).
 - 2. Provide an interface (dry contact closure) between the PACS and the UPS system so the UPS trouble signals and main power fail appear on the PACS operator terminal as alarms.
 - 3. UPS for security equipment shall have the capacity to provide one (1) hour of service.
 - 4. All UPS for security equipment must have 20% extra capacity for future expansion.
 - 5. Dedicated UPS units shall not be floor mounted unless in the UCR. All other UPS units shall be rack mounted.
- D. Power Supplies
 - 1. The switch from primary power to generator shall generate an AC Fail alarm on the PACS.
 - 2. Detect and report on the PACS failure of any battery as a fault condition.
 - 3. Size battery backed-up power supplies for eight (8) hours of operation at actual connected load.
 - 4. All power supplies for security equipment must have 20% extra capacity for future expansion.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. PACS Power Supplies
 - 2. UPS

1.4 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 ISTAR ENCLOSURE / POWER SUPPLY

A. Acceptable Manufacturers

1. Life Safety Power

B. Life Safety Power Flex FPO150/250-2D82M8NL4E8S/T16-B, Pre-wired 16 Door Access Dual Voltage Enclosure / Power Supply

C. Minimum Features and Specifications

1. Input Power

- a. Input 120 VAC 50 Hz 452 Watts
- b. Overload and short circuit protection
- c. Over temperature protection
- d. Polarized AC power supply disconnect

2. Output Power

- a. FPO150: 12V/12A 150 Watts
- b. FPO250: 24V/10A 250 Watts
- c. Outputs: Continuous (DC1) Resettable (DC2)
- d. 16 managed control outputs, fused at 3A each
- e. 16 auxiliary outputs, fused at 3A each
- f. 120 mV output voltage ripple
- g. System Efficiency: 87%
- h. System BTU Rating: 175 BTU/Hr

3. Battery Charging

- a. Independent built-in 2A charger for sealed lead acid or gel type batteries
- b. Microprocessor dual rate charging of 12 or 24 V battery sets
- c. Charges up to 80Ah battery sets within UL limit
- d. Automatic switchover to standby battery when AC fails
- e. Zero voltage drop when switched over to battery backup

4. Supervision

- a. AC Fail (form "C" contacts)
- b. System Fault (form "C" contacts) may be triggered by low/no battery, short to earth ground, power supply failure or blown fuse

5. Visual Indicators
 - a. AC input, DC1 and DC2 output
 - b. System fault
 - c. AC fault
 - d. Short to earth ground
 - e. Reverse battery polarity
 - f. Fire Alarm Input activated
 - g. D8: DC outputs
 - h. M8: DC inputs, outputs and fault
6. Regulatory Compliance (LSP equipment)
 - a. UL294, UL603, UL1076
 - b. ULC S318, ULC S319, CSA C22.2 #107.1, CSA C22.2 #60950
 - c. FCC Part 15, Subpart B / CSFM Approved
7. Physical Dimensions Enclosure: (H x W x D) 36 x 30 x 4.5 in (91 x 76 x 11.5 cm)
8. Connect tamper and power outputs to the unsupervised inputs on the associated DGP.
9. Annunciate the following conditions on the security management system: cabinet tamper, AC power fail, and low battery.

2.2 UNINTERRUPTIBLE POWER SUPPLY

- A. Acceptable Manufacturers
 1. APC
- B. APC Smart UPS SMT2200RM2UC or approved equivalent
- C. Minimum Features and Specifications
 1. Automatic voltage regulation and surge protection
 2. Two (2) rack units high
 3. 1920 W / 1920 VA
 4. Surge energy rating or 459 Joules
 5. Maximum depth is 18 in (46 cm)
- D. Additional Required Options / Parts
 1. UPS Network Management Card with Environmental Monitoring AP9631 or approved equivalent
 - a. Enables secure monitoring and control of an individual UPS via Web browser, CLI, or SNMP

2.3 UPS, SERVER

A. Acceptable Manufacturers

1. APC

B. APC Smart UPS SMX3000RMLV2U or approved equivalent

C. Minimum Features and Specifications

1. Automatic voltage regulation and surge protection
2. 2,700 W / 2,880 VA
3. Total of four (4) rack units high (UPS and Battery Pack)
4. Surge energy rating of 540 Joules
5. Maximum depth is 26 in (66 cm)

D. Additional Required Options / Parts

1. UPS Network Management Card with Environmental Monitoring AP9631 or approved equivalent
 - a. Enables secure monitoring and control of an individual UPS via Web browser, CLI, or SNMP
2. Battery Pack SMX120RMBP2U or approved equivalent

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 280507.10

SECTION 28 0509.10 - SURGE PROTECTION FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. This specification is for surge protection for electronic security systems (ESS).
- B. Transient Voltage Surge Suppression:
 - 1. Protect cables and conductors extending beyond building façade, except fiber optic cables, which serve as communication, control, or signal lines against Transient Voltage surges and have Transient Voltage Surge Suppression (TVSS) protection.
 - 2. The TVSS device shall be UL listed in accordance with Standard TIA 497B.
 - 3. Lighting and surge suppression shall be a multi-strike variety and include a fault indicator.
 - 4. Provide protection at the field device and on each wire line circuit at the first accessible location within the building but not more than 50 ft (15 m) of the building cable entrance.
 - 5. Fuses shall not be used for surge protection.
 - 6. Test the inputs and outputs in both normal mode and common mode to verify there is no interference.
 - 7. General Performance Requirements.
 - a. A 10-microsecond rise time by 1000 microsecond pulse width waveform with a peak voltage of 1500 volts and a peak current of 60 amperes.
 - b. An 8-microsecond rise time by 20-microsecond pulse width waveform with a peak voltage of 1000 volts and a peak current of 500 amperes.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. TVSS

1.4 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 TVSS, POWER

- A. Acceptable Manufacturers
 - 1. Ditek
 - 2. Approved Equivalent
- B. Ditek DTK-4LVLPCR or approved equivalent
- C. Minimum Features and Specifications
 - 1. Suitable for surface mounting or DIN rail (DTK_DRK required) within the enclosure/rack
 - 2. Protects power (12V / 24V), data and LED circuits
 - 3. Connection Method #22 - #16 AWG screw terminals
 - 4. Single ground point for all protected circuits
 - 5. Operating Temperature: -40 to 158 deg F (-40 to 70 deg C)

2.2 TVSS, ETHERNET POE

- A. Ditek DTK-MRJPOES or approved equivalent
- B. Minimum Features and Specifications
 - 1. Suitable for surface mounting or DIN rail (DTK_DRK required) within the enclosure/rack
 - 2. Protects power, video and data PoE circuits
 - 3. RJ45 connection with external grounding screw
 - 4. Operating Temperature: -40 to 158 deg F (-40 to 70 deg C)

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

3.2 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 280509.10

FOR REFERENCE ONLY

SECTION 28 0531.10 - COMMUNICATIONS EQUIPMENT FOR ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. This specification is for the communications equipment directly supporting the electronic security systems (ESS).

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Network Switches
 - 2. Fiber Switches
 - 3. Fiber Modules

1.4 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 NETWORK SWITCH – 48 PORT

- A. Acceptable Manufacturers
 - 1. Cisco
- B. Cisco Catalyst 3850 Series WS-C3850-48P-E with C3850-NM-2-10G or approved equivalent
- C. Minimum Features and Specifications
 - 1. Forty-eight (48) 10/100/1000 PoE ports
 - 2. Two (2) 10 Gigabit Ethernet SFP+/ Gigabit Ethernet SFP ports
 - 3. Four (4) SFP+ modules rated for 400M over MM OM4 cable
 - 4. Redundant power supplies

5. Switching capacity of 176 Gbps
6. Eight (8) GB of DRAM
7. Eight (8) GB Flash
8. MTBF of 241,050 hours
9. EIGRP routing
10. Universal k9 image
11. 24/7/365 hardware and software support from OEM with 4-hour onsite parts.

D. Additional Required Options / Parts

1. C3850-NM-2-10G
2. Four (4) Cisco SFP-10G-SR (Two for access switch and two for core)
3. Two (2) Cisco PWR-C1-715WAC power supplies
4. Provide StackWise connection of network and fiber switches in the same rack or cabinet
5. Enable StackPower in stacks of network and fiber switches in redundant mode
 - a. In redundant mode, when the total power budget of the stack is calculated, the wattage of the largest power supply is not included. That power is held in reserve and used to maintain power to switches and attached devices when one power supply fails, enabling the network to operate without interruption. Following the failure of one power supply, the StackPower mode becomes power sharing.

2.2 NETWORK SWITCH – 24 PORT

A. Acceptable Manufacturers

1. Cisco

B. Cisco Catalyst 3850 Series WS-C3850-24P-S with C3850-NM-2-10G or approved equivalent

C. Minimum Features and Specifications

1. Twenty-four (24) 10/100/1000 copper PoE ports
2. Two (2) 10 Gigabit Ethernet SFP+ / Gigabit Ethernet SFP ports
3. Four (4) SFP+ modules rated for 400M over MM OM4 cable
4. Redundant power supplies
5. Switching capacity of 92 Gbps
6. Four (4) GB of DRAM
7. Two (2) GB Flash
8. MTBF of 269,450 hours
9. EIGRP routing
10. Universal k9 image
11. 24/7/365 hardware and software support from OEM with 4-hour onsite parts.

D. Additional Required Options / Parts

1. C3850-NM-2-10G
2. Four (4) Cisco SFP-10G-SR (Two for access switch and two for core)
3. Two (2) Cisco PWR-C1-715WAC power Supplies

4. Provide StackWise connection of network and fiber switches in the same rack or cabinet
5. Enable StackPower in stacks of network and fiber switches in redundant mode.
 - a. In redundant mode, when the total power budget of the stack is calculated, the wattage of the largest power supply is not included. That power is held in reserve and used to maintain power to switches and attached devices when one power supply fails, enabling the network to operate without interruption. Following the failure of one power supply, the StackPower mode becomes power sharing.

FOR REFERENCE ONLY

2.3 FIBER SWITCH

A. Acceptable Manufacturers

1. Cisco

B. Cisco Catalyst 3850 Series WS-C3850-48XS-E or approved equivalent

C. Minimum Features and Specifications

1. Forty-eight (48) SFP+ ports
2. Furnish with (2) PWR-C1 750WAC power supplies
3. Switching capacity of 1280 Gbps
4. Eight (8) GB of DRAM
5. Eight (8) GB Flash
6. MTBF of 286,900 hours
7. EIGRP routing
8. Universal k9 image
9. 24/7/365 hardware and software support from OEM with 4-hour onsite parts.

D. Additional Required Options / Parts

1. Four (4) Cisco SFP-10G-SR (For connection between core switches)
2. Two (2) Cisco PWR-C1 750WAC power supplies

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 IP ADDRESSING

- A. Refer to 280500.10 Submittals for requirements.

3.3 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 280531.10

FOR REFERENCE ONLY

SECTION 28 0800.10 - COMMISSIONING OF ELECTRONIC SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. This specification is for the commissioning of electronic security systems (ESS).

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Commissioning of the Electronic Security Systems

1.4 REFER TO 280500.10 FOR ALL OTHER PART 1 REQUIREMENTS

PART 2 - PRODUCTS

2.1 THERE ARE NO PRODUCTS IN THIS SPECIFICATION

PART 3 - EXECUTION

3.1 PERFORMANCE REQUIREMENTS

- A. General
 - 1. Refer to Project Process Diagram (PPD) in 280500.10. Utilize the PPD to develop effective and timely project schedules and submissions to ensure project is substantially complete prior to occupancy.

3.2 CONTRACTOR'S FIELD TESTING

- A. Perform the Contractor Field Test (CFT) of all devices utilizing OPS provided forms.
- B. Submit test results, including journal logs from CCURE, to COTR and OPS-PPSD.

3.3 PERFORMANCE VERIFICATION TEST (PVT)

- A. Based on the OPS-PPSD approval of the Contractor's Field Test, the COTR will schedule the PVT with the Contractor and OPS-PPSD.

Request from OPS whether this project requires a full PVT or Partial PVT and select the appropriate paragraph below.

- B. OPS-PPSD will witness the Contractor conduct the PVT of all devices utilizing the same form as for the CFT.
- C. OPS-PPSD reserves the right to stop and abort testing as soon as 10 technical deficiencies are found requiring correction.
 - 1. If the acceptance test is aborted, the re-test will commence from the beginning with a retest of components previously tested and accepted.
 - 2. The Contractor is responsible for all time, travel, and lodging expenses incurred for personnel required to be present for resumption of the PVT.
- D. The PVT also includes a physical inspection of the installation quality and workmanship.
- E. Submit test results, including journal logs from CCURE, to COTR and OPS-PPSD.

3.4 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 280800.10

SECTION 28 1000 - ACCESS CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. The physical access control system (PACS) is an enterprise class system with intrusion detection inherent to the PACS controllers. The PACS is the central system for the entire electronic security system. Integrate all other systems (intrusion detection, intercommunications, and video) with the PACS so the PACS provides a single unified control and management platform.
- B. This is an extension of the Owner's existing Software House C•CURE 800/8000 system.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. PACS Panels
 - 2. Reader Module
 - 3. Card readers

1.4 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 PACS SOFTWARE

- A. Software Licensing

Confirm PACS licensing with OPS.

- 1. The existing Software House PACS license will support this project.

***** [OR] *****

- 2. Upgrade existing site license to Software House PACS license [10][20][30][40].

B. Software Integrations

1. Video Assessment and Surveillance System (VASS) functionality
 - a. Control of cameras through the PACS and graphic maps
 - b. Associate cameras with access control and alarm events
2. Intercom functionality
 - a. Control of intercoms through the PACS and graphic maps
 - b. Associate cameras with intercom calls

2.2 ISTAR ULTRA SE

A. Acceptable Manufacturers

1. Software House

B. Software House iSTAR Ultra SE

C. Minimum Features and specifications

1. Furnish with both ACMs
2. FIPS 140-2 Complaint
3. Install GCM and ACMs in Life Safety Power enclosure
4. Provide Life Safety Power power supply as specified in 280507.10 – Power Sources for Electronic Security

2.3 ISTAR EX-4

A. Acceptable Manufacturers

1. Software House

B. Software House iSTAR ex 4-door controller

C. Minimum Features and specifications

1. Work with C•CURE 800/8000 and C•CURE 9000
2. Onboard FIPS 140-2 validated AES encryption
3. FIPS 197-validated 256-bit encryption
4. Built-in UPS with 17 Ahr SLA battery providing full operational backup for four hours, with a 24 hour recharge time
5. 16 supervised inputs
6. 4 Form C relays
7. UL294 and UL1076

2.4 READER MODULE

- A. Acceptable Manufacturers
 - 1. Software House
- B. Software House RM-4E or approved equivalent
- C. Minimum Features and specifications
 - 1. RM-DCM-2 UL Listed tamper protected enclosure
 - 2. RM-4E module

2.5 CARD READER, STANDARD

- A. Acceptable Manufacturers
 - 1. Identiv
 - 2. Software House
 - 3. Approved Equivalent

FOR REFERENCE ONLY

B. The following readers are tested and acceptable

1. Identiv 8110ABPOOOO-TS449 Standard (Pigtail)
2. Identiv 8110ABTOOOO-TS449 Standard (Terminal Plug)
3. SWH-4130 Standard Reader (Terminal Plug)

C. Minimum Features and specifications

1. Works with C•CURE 800/8000 and C•CURE 9000
2. Read within 3 inches
3. Standard firmware that allows field programming no matter the model
4. Single-gang mounting
5. Black
6. Environmental
 - a. IP65 Pigtail models
 - b. IP55 Terminal models
 - c. Temperature range: -31 to 149 deg F (-35 to 66 deg C)
7. Terminal strip is preferred
8. Low Frequency Card Compatibility (125 kHz)
 - a. Indala
9. High Frequency Card Compatibility (13.56 MHz)
 - a. PIV
 - b. PIV-I
 - c. Mi-Fare Classic
 - d. DESFire EV1
 - e. PLAID
 - f. ISO 15693
 - g. ISO 14443 A/B

2.6 CARD READER, MULLION

A. Acceptable Manufacturers

1. Software House
2. Identiv
3. Approved Equivalent

B. The following readers are tested and acceptable

1. Identiv 8010ABTOOOO-TS449 Mullion (Terminal Plug)
2. Identiv 8010ABPOOOO-TS449 Mullion (Pigtail)

C. Minimum Features and specifications

1. Works with C•CURE 800/8000 and C•CURE 9000
2. Read within 3 inches
3. Standard firmware that allows field programming no matter the model
4. Dimensions: 4.6 x 1.7 x 1.1 in (118 x 43 x 28 mm)
5. Black
6. Environmental
 - a. IP65 Pigtail models
 - b. IP55 Terminal models
 - c. Temperature range: -31 to 149 deg F (-35 to 66 deg C)
7. Terminal strip is preferred
8. Low Frequency Card Compatibility (125 kHz)
 - a. Indala
9. High Frequency Card Compatibility (13.56 MHz)
 - a. PIV
 - b. PIV-I
 - c. Mi-Fare Classic
 - d. DESFire EV1
 - e. PLAID
 - f. ISO 15693
 - g. ISO 14443A/B

2.7 CARD READER, KEYPAD

A. Acceptable Manufacturers

1. Software House
2. Identiv
3. Approved Equivalent

B. The following readers are tested and acceptable

1. SWH-4230 Standard Reader with Keypad (Terminal Plug)
2. Identiv 821 OABTOOOO-TS449 Standard with keypad (Terminal Plug)

C. Minimum Features and specifications

1. Works with C•CURE 800/8000 and C•CURE 9000
2. Read within 3 inches
3. Standard firmware that allows field programming no matter the model
4. Single-gang mounting
5. Black
6. Environmental
 - a. IP65 Pigtail models
 - b. IP55 Terminal models
 - c. Temperature range: -31 to 149 deg F (-35 to 66 deg C)
7. Terminal strip is preferred
8. Low Frequency Card Compatibility (125 kHz)
 - a. Indala
9. High Frequency Card Compatibility (13.56 MHz)
 - a. PIV
 - b. PIV-I
 - c. Mi-Fare Classic
 - d. DESFire EV1
 - e. PLAID
 - f. ISO 15693
 - g. ISO 14443A/B

2.8 CARD READER, ARM/DISARM

A. Acceptable Manufacturers

1. Software House
2. Approved Equivalent

B. The following readers are tested and acceptable

1. SWH RM2L-4000-P126 Reader with LCD display and keypad

C. Minimum Features and specifications

1. Works with C•CURE 800/8000 and C•CURE 9000
2. Read within 3 inches
3. Standard firmware that allows field programming no matter the model
4. Black
5. Environmental
 - a. Temperature range: -31 to 149 deg F (-35 to 66 deg C)
6. Low Frequency Card Compatibility (125 kHz)
 - a. Indala
7. High Frequency Card Compatibility (13.56 MHz)
 - a. PIV
 - b. PIV-I
 - c. Mi-Fare Classic
 - d. DESFire EV1
 - e. PLAID
 - f. ISO 15693
 - g. ISO 14443A/B

Add additional project specific products as required using the format below.

2.9 AUTOMATIC ROOF HATCH OPENER

A. Acceptable Manufacturers

1. SafePro
2. Approved Equivalent

B. SafePro HandsFree Power Hatch Lift

C. Minimum Features and Specifications

1. OSHA compliant
2. Hands-free open / close / lock / unlock
3. Retrofit to any size hatch
4. Restrict unauthorized rooftop access
5. Track approved users and access duration
6. Integrate with existing security system for remote release

2.10 [TBD]

A. Acceptable Manufacturers

1. [TBD]
- B. [TBD] [TBD] or approved equivalent
- C. Minimum Features and specifications
 1. [TBD]

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 GENERAL

- A. Install all system components and appurtenances in accordance with the manufacturers' instructions, ANSI C2, and furnish all necessary interconnections, services, and adjustments required for a complete and operable system as specified. Install control signals, communications, and data transmission lines grounding as necessary to preclude ground loops, noise, and surges from affecting system operation. Equipment, materials, installation, workmanship, inspection, and testing shall be in accordance with manufacturers' recommendations and as modified herein.
- B. Consult the manufacturers' installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the Riser/Connection diagram for schematic system installation/termination/wiring data.
- C. Attach equipment to walls and ceiling/floor assemblies and held firmly in place (e.g., sensors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.

3.3 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with EIA/TIA-606, "Administration Standard for the Telecommunications Infrastructure of Commercial Buildings."

3.4 CURRENT SITE CONDITIONS

- A. Visit the site and verify site conditions are in agreement with the design package. Report changes to the site or conditions which will affect performance of the system to the COTR and PPSPD-Security System Engineer in a report. The Contractor shall not take any corrective action without written permission from the COTR.

3.5 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to PCs, Controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after correcting unsatisfactory conditions.

3.6 ELEVATOR TRANSITION BOX

- A. Provide a 12 x 12 in (305 x 305 mm) NEMA 4 enclosure in the Elevator Equipment Room. This is a transition point between Division 14 cabling and Division 28 cabling.

3.7 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 281000

SECTION 28 1515 - ELECTRIFIED LOCKING DEVICES AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 280500.10 Common Work Results for Electronic Security.

1.2 SYSTEM DESCRIPTION

- A. This specification is electrified locking devices and accessories in support of the FACS directly supporting the electronic security systems (ESS). All locking and access control must comply with NFPA 101. Coordinate with Division 08 requirements.

1.3 SUMMARY

- A. This Section includes the following:
 - 1. Passive Infrared Request to Exit (PIR Rex)
 - 2. Sounders
 - 3. Delayed Egress Locks
 - 4. Electrified Locks
 - 5. Electric Strikes
 - 6. Electric Hinges (by Division 08)
 - 7. Electronic Pass-through Hinges (by Division 08)

1.4 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 PIR REQUEST TO EXIT

- A. Acceptable Manufacturers
 - 1. Bosch Security Systems
- B. Bosch DS-160 or DS-161 or approved equivalent.
- C. Minimum Features and Specifications

D. Request To Exit Detectors:

1. Passive infrared sensor designed for wall or ceiling mounting 7.5 to 15 ft (2.1 to 4.6 m)
2. Provide two (2) form "C" (SPDT) relays rated one (1) Amp. @ 30 VDC for DC resistive loads
3. The detectors relays shall be user adjustable with a latch time from 0.5-64 seconds. The detector shall also include a selectable relay reset mode to follow the timer or absence of motion.
4. Adjustable detection pattern plus or minus fourteen (± 14) degrees
5. Operate on 12 VDC with approximately 39 mA continuous current draw
6. Measure approximately 1.8 x 6.75 x 1.75 in (45 x 171 x 44 mm)

2.2 LOCAL SOUNDER

A. Acceptable Manufacturers

1. Mallory

B. Mallory SC 616N and SC 616CP or approved equivalent.

C. Minimum Features and Specifications

1. Local alarms shall be provided for all perimeter doors and card access controlled doors. All card access controlled doors receive local sounders. The local perimeter door alarms shall be a steady tone (SC 616N) while the card access controlled doors shall have a chime tone (SC 616CP).
2. The local sounder shall be a solid state sounding device with no moving parts. The sounder shall operate on 6-16 VDC at less than 16mA draw and produce a 2900 Hz signal at approximately 80-95 dB dependent upon input power. Sounders shall be powered by the auxiliary power supply. The power circuits supplying power to local sounders shall have an individual fuse for each positive leg between the main power supply output and individual distribution circuit. The fuse shall be rated at 50% of the rating of the fuse protecting the power supply output. The sounder shall be plate mounted to a recessed mounted junction box above and immediately adjacent the protected opening. Where the door is controlled by a card reader, the local sounder may be located on the reader module junction box providing the box is located immediately adjacent the protected opening and not obscured by ceiling tiles. The sounder shall be located on the secure side of the protected opening. The sounding device shall be activated and reset via the security management system. Each sounder shall be controlled by an individual relay at the DGP or at field relay modules. Reset or silencing of the sounder shall be via the control room operator terminals.

2.3 DELAYED EGRESS DEVICE

A. Acceptable Manufacturers

1. SDC
2. Approved Equivalent

- B. SDC-101KDE-NA Series or approved equivalent
- C. Minimum Features and Specifications
 - 1. 15 or 30 seconds exit delay
 - 2. 1 or 2 seconds nuisance delay
 - 3. Digital countdown display
 - 4. Field selectable voice notification or tone
 - 5. Wall mount controller with keyswitch control and reset (cylinder provided by SI OPS)
- D. Additional Required Options / Parts
 - 1. SDC-1571V Series electromagnetic lock with activation sensor or approved equivalent
 - a. 1200 lbs. (544 kg) holding force
 - b. 250/125 mA at 12/24 VDC
 - c. Request to Exit output via micro-switch in push bar

2.4 ELECTRIFIED MORTISE LOCKSET WITH INTEGRATED REX

- A. Acceptable Manufacturers
 - 1. Sargent
 - 2. Schlage
 - 3. Yale
- B. Sargent Ecoflex 8200 or approved equivalent.
- C. Minimum Features and Specifications
 - 1. ANSI/BHMA certified extra heavy duty, lever type mortise lock conforming to ANSI/BHMA 156.13 Series 1000, Grade 1 requirements and ANSI A117.1 accessibility guidelines. All functions manufactured in a single sized case formed from a minimum 12 gauge steel.
 - 2. Lockset is field-adjustable for handing without opening the lock body with a beveled armored front that is 0.125 in (3.175 mm) minimum thickness and utilizes a one-piece 3/4" anti-friction stainless steel latchbolt. To insure proper alignment, all trim, shall be thru-bolted and fully interchangeable between rose and escutcheon designs.
 - 3. Lock is UL listed and labeled for use on up to 3 hour fire rated openings.
 - 4. Locking and unlocking of the lever handle by electronic operation contained completely within the body of the mortise lock.
 - 5. Field configurable Fail Safe /Fail Secure by means of an external DIP switch setting.
 - 6. Operationally voltage-insensitive 12 to 24 VDC.
 - 7. Energy Performance: Maximum standby current required for functional operation not to exceed 50 mA at 24 VDC limiting potential inductive kickback or the need for external diodes.
 - 8. Valid egress signaled by activation of the Request-to-Exit (RX) micro switch integral to the inside lever of the lockset on the unsecure side of the door capable of shunting external alarms.

9. Compatible with Schlage lever handles
10. 2 year limited warranty on electrified locks

2.5 ELECTRIC STRIKE

A. Acceptable Manufacturers

1. HES

B. HES 1006 series or approved equivalent.

C. Minimum Features and Specifications

1. UL 10C fire-rated, 3 hour single door (fail secure only)
2. UL 10C fire-rated, 1-1/2 hour double door (fail secure only)
3. ANSI A250.13-2003 windstorm listed
4. UL 1034 burglary-resistant listed and suitable for outdoor use
5. ANSI/BHMA A156.31, Grade 1
6. NFPA-252 fire door conformant
7. ASTM-E152 fire door conformant
8. Capable of use on metal and wood frames
9. Dual voltage 12 or 24VDC continuous duty
10. 0.45 Amps @ 12VDC* continuous duty
11. 0.25 Amps @ 24VDC* continuous duty
12. Stainless steel construction
13. Tamper resistant
14. Static strength 3070 lbs. (1,393 kg) (fail secure)
15. Dynamic strength 350 ft-lbs. (475 N m) (fail secure)
16. Endurance 1,000,000 cycles
17. Fail secure (standard)
18. Non-handed
19. Internally mounted solenoid
20. Accommodates up to 1 in (25.4 mm) deadbolt
21. Plug-in connector
22. Full keeper shims for horizontal adjustment
23. Trim enhancer
24. Five year limited warranty

2.6 ELECTRIC STRIKE, PANIC HARDWARE

A. Acceptable Manufacturers

1. HES

B. HES 9400 series or approved equivalent.

C. Minimum Features and Specifications

1. ANSI/BHMA A156.31, Grade 1
2. Capable of use on metal and wood frames
3. Dual voltage 12 or 24VDC continuous duty
4. 0.45 Amps @ 12VDC* continuous duty
5. 0.25 Amps @ 24VDC* continuous duty
6. Completely surface mounted
7. Stainless steel construction
8. Tamper resistant
9. Static strength 1,500 lbs. (680 kg)
10. Dynamic strength 70 ft-lbs. (95 N m)
11. Endurance 500,000 cycles
12. Included 0.125 in (3.175 mm) spacer plate
13. Field selectable fail safe/fail secure
14. Horizontal adjustment
15. Non-handed
16. Internally mounted solenoid
17. Accommodates up to 0.5 in (12.7 mm) Pullman latch
18. Five year limited warranty

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 GENERAL

- A. Coordinate with Division 8 requirements, finishes, and keyways.
- B. OPS Lock Shop will rekey project provided cores. Coordinate with the OPS Lock Shop to purchase correct cylinder/cores.
- C. Only Software House certified integrators may terminate cabling on PACS equipment.

3.3 REFER TO 280500.10 AND 281000 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 280515

SECTION 28 1523 - INTERCOM ENTRY SYSTEMS

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. This is an extension of the Owner's existing Vingtor-Stentofon system.

Select one of the following paragraphs.

- B. The existing system head-end in Police Department has expansion capacity to accommodate the new intercoms. The Contractor is responsible for licenses.

***** [OR] *****

- ~~C. Provide a new intercom server as listed in 280513.10 Servers, Workstations, and Storage for Electronic Security with all associated licenses.~~

1.2 SUMMARY

- A. This Section includes the following:

1. Intercom
2. Video Intercom
3. Elevator Intercom

1.3 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 INTERCOM

- A. Acceptable Manufacturers

1. Vingtor-Stentofon

- B. Vingtor-Stentofon TCIS-3 with adapter plate or approved equivalent.

- C. Minimum Features and Specifications

1. IP 65 rated
2. Black Thermoplastic front plate with single button
3. Noise cancelling – suppression of musical noise
4. Noise cancelling - suppression of static noise
5. Noise cancelling - suppression of rapidly changing noise

6. Scream Alarm
7. PoE 802.3af, Class 0 (0.44W to 12.95W)
8. Operating temperature range -13 to 158 deg F (-25 to 70 deg C)

2.2 VIDEO INTERCOM

A. Acceptable Manufacturers

1. Vingtor-Stentofon

B. Vingtor-Stentofon TCIV-3 with adapter plate or approved equivalent.

C. Minimum Features and Specifications

1. Integral HD video camera (720p) at 25 frames per second
2. IP 65 rated
3. Black Thermoplastic front plate with single button
4. Noise cancelling – suppression of musical noise
5. Noise cancelling - suppression of static noise
6. Noise cancelling - suppression of rapidly changing noise
7. Scream Alarm
8. PoE 802.3af, Class 0 (0.44W to 12.95W)
9. Operating temperature range -13 to 158 deg F (-25 to 70 deg C)

2.3 VIDEO INTERCOM MASTER

A. Acceptable Manufacturers

1. Vingtor-Stentofon

B. Vingtor-Stentofon 1408001635 with adapter plate or approved equivalent.

C. Minimum Features and Specifications

1. Designed to deliver Critical communication over IP
2. Call queue according to priority and time of call, 256 priority levels
3. Ten (10) DAKS provide single-touch access to stations, group calls, audio monitoring, public address zones, radio channels and telephone lines
4. Comes with handset for private conversations
5. Superb audio quality-high bandwidth codec, active noise cancellation, acoustic echo cancellation, and high output power amplifier
6. 3.5" LCD touchscreen display with the capability of displaying pictures from an IP video camera
7. Remote software upgrade, configuration and monitoring
8. Audio: 1.5 W speaker output @ 8 ohm
9. Display: 3.5" TFT with touchscreen panel, LED backlight (white)
10. Ethernet: 1 x RJ45 10/100 Mbps with PoE
11. Operational Voltage: Power over Ethernet 802.3af, Class 0

12. Environmental Conditions: -4 to 131 deg F (-20 to 55 deg C)

2.4 ELEVATOR KIT

A. Acceptable Manufacturers

1. Vingtor-Stentofon

B. Vingtor-Stentofon IP Substation Kit 1008090200 or approved equivalent.

C. Minimum Features and specifications

1. Dimensions (HxWxD) 4.33 x 2.83 x 0.79 in (110 x 72 x 20 mm)
2. Call buttons Connection for 3 NO contacts
3. Mounting Inside custom made stations
4. Temperature -58 to 131 deg F (-50 to 55 deg C)
5. Relative humidity 0% - 95%
6. Power over Ethernet, IEEE 802.3 a-f, Class 0, Local power 19 – 27 VDC, Idle 4W, max. 8W
7. Connectors 2 x RJ45 (Ethernet) 10/100 Mbps, Pluggable screw terminals (audio and IO)
8. Remote control, Max. switching capacity,
9. LAN protocols
 - a. Power over Ethernet (IEEE 802.3 a-f)
 - b. VLAN (IEEE 802.1pq)*
 - c. Network Access Control (IEEE 802.1x)*
 - d. STP (IEEE 802.1d)
 - e. RSTP (IEEE 802.1d-2004)
10. Audio technology
 - a. Wideband 200 Hz - 7 kHz (G.722)
 - b. Telephony 3.4kHz (G.711, Acoustic echo cancellation, Open duplex, Adaptive jitter filter, 1.5 Watt audio output, 8 ohm loudspeaker impedance, External audio output (0 dB, 600 ohm)
11. Management and operation
 - a. HTTPS (Web configuration)
 - b. DHCP and static IP
 - c. Remote automatic software upgrade
 - d. Centralized monitoring
 - e. Status LED
12. Dual port managed data switch supporting VLAN and network access control
13. Compliance CE and FCC Part 15

D. Additional Required Options / Parts

1. Mounting and Assembly Kit 1008091000 including gaskets, two inch loudspeaker, loudspeaker housing and mounting block for call LED and microphone

Add additional project specific products as required using the format below.

2.5 ~~— [TBD]~~

~~A. Acceptable Manufacturers~~

~~1. [TBD]~~

~~B. [TBD] [TBD] or approved equivalent~~

~~C. Minimum Features and specifications~~

2.6 ~~— [TBD]~~

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 INTERCOMMUNICATION SYSTEMS

A. Installation

1. Install all system components including Owner furnished equipment, and appurtenances in accordance with the manufacturer's instructions, ANSI C2 and as shown including all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable duress communications system.

B. Tamper Resistant Substations

1. Locate substations where shown on the drawings. Provide recessed back boxes in which the substation operating mechanisms shall be mounted. Mount substation with the call button centerline no higher than 42 in (1100 mm) above the finished floor.

Retain the following paragraph if the project has elevator intercoms.

3.3 ELEVATOR TRANSITION BOX

- A. Provide a 12 x 12 in (305 x 305 mm) NEMA 4 enclosure in the Elevator Equipment Room. This is a transition point between Division 14 cabling and Division 28 cabling.

3.4 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 281523

SECTION 28 2000 - VIDEO

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. The Video Assessment and Surveillance System (VASS) is an enterprise class system. Integrate with the PACS so the PACS provides a single unified control and management platform. Link video to events and alarms on all other systems (intrusion detection, intercommunications, and PACS) with the PACS.
- B. This is an extension of the Owner's existing American Dynamics Victor system.
- C. The existing system head-end in NMNH has expansion capacity to accommodate the new cameras. The Contractor is responsible for licenses.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Cameras
 - 2. Network Video Recorder
 - 3. Wall Mounted Equipment Rack Enclosure

1.3 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 MULTI-LENS DOME CAMERA

- A. Acceptable Manufacturers
 - 1. Axis
 - 2. HanWha
 - 3. Approved Equivalent
- B. AXIS 3748 PLE or approved equal. Where cameras are discontinued, submit manufacturer recommended replacement for approval.
- C. Mounts
 - 1. Wall Mounted Conditions
 - a. Axis Pendant Kit TP3107
 - b. Axis Pendant Adaptor Hanging Mount T91B50
 - c. Axis TM3101 modified to mount Hanging Mount
 - 2. Ceiling Mount Conditions
 - a. Recessed Ceiling Mount

2.2 FIXED DOME CAMERA, 8MP

- A. Acceptable Manufacturers
 - 1. AXIS
 - 2. HanWha
 - 3. Approved Equivalent
- B. AXIS P3268-PVE or approved equivalent. Where cameras are discontinued, submit manufacturer recommended replacement for approval.
- C. Minimum Features and specifications
- D. Mounts
 - 1. AXIS TP3005-E Wall Mount
 - 2. AXIS TP3201-E Recessed Mount
 - 3. AXIS TP3103-E Pendant Kit

2.3 DIGITAL VIDEO RECORDER

- A. Acceptable Manufacturers
 - 1. American Dynamics
 - 2. No Other Equivalent

- B. American Dynamics ADVER96R5DK VideoEdge Rack Mounted Network Video Recorder, RAID 5, Dual PSU, 96TB
- C. Where product is discontinued, submit manufacturer recommended replacement for approval.

2.4 WALL MOUNTED EQUIPMENT ENCLOSURE

- A. Acceptable Manufacturers
 - 1. Mid-Atlantic DWR -24-32
 - 2. Approved Equivalent

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 GENERAL

- A. Install all system components and appurtenances in accordance with the manufacturer's instructions, ANSI C2, and furnish all necessary interconnections, services, and adjustments required for a complete and operable system as specified. Control signals, communications, and data transmission lines grounding shall be installed as necessary to preclude ground loops, noise, and surges from affecting system operation. Equipment, materials, installation, workmanship, inspection, and testing shall be in accordance with manufacturers' recommendations and as modified herein.
- B. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation. Refer to the Riser/Connection diagram for all schematic system installation/termination/wiring data.
- C. Attach equipment to walls and ceiling/floor assemblies and be held firmly in place (e.g., sensors shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
- D. Current Site Conditions: Visit the site and verify site conditions are in agreement with the design package. Report all changes to the site or conditions that will affect performance of the system to the Owner. Do not take any corrective action without written permission from the Owner.
- E. Cameras
 - 1. Install cameras with the proper focal length lens as indicated for each zone
 - 2. Set cameras with fixed iris lenses to the proper f-stop to give full video level

3. Aim camera to give field of view as needed to cover the alarm zone / intended field of view
 4. Aim fixed mount cameras installed outdoors facing the rising or setting sun sufficiently below the horizon to preclude the camera looking directly at the sun
 5. Focus the lens to give a sharp picture over the entire field of view.
 6. Use a fine focus target for final focus adjustments.
- F. Camera Pole and Mounts: The Contractor shall install the camera mount as specified by the manufacturer and as shown; provide mounting hardware sized appropriately to secure the mount, camera and housing with maximum wind and ice loading encountered at the site; provide a foundation for each camera pole as specified and shown; provide a ground rod for each camera pole of correct length as dictated by soil conductivity and connect the camera pole to the ground rod; provide electrical and signal transmission cabling to the mount location; connect signal lines and AC power to mount interfaces; connect pole wiring harness to camera.

3.3 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video surveillance system components, including camera-housing windows, lenses, and monitor screens.

3.4 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 282000

SECTION 28 3100 - INTRUSION DETECTION

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

- A. The Intrusion Detection System is an inherent part of the PACS system. Link alarms to video system for event driven camera call-up and recording.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Door contacts
 - 2. Glass breaks
 - 3. Motion sensors

1.3 REFER TO 280500.10 FOR ALL OTHER PART I REQUIREMENTS

PART 2 - PRODUCTS

2.1 ~~CARD READER, ARM/DISARM~~

A. ~~Refer to 281000 Access Control for specifications~~

2.2 ~~360 DEGREE DUAL TECH MOTION SENSOR~~

A. ~~Acceptable Manufacturers~~

1. ~~Bosch~~
2. ~~Approved Equivalent~~

B. ~~Bosch DS9370 and DS9371 or approved equivalent.~~

C. ~~Minimum Features and Specifications~~

1. ~~Up to 25 ft (7.6 m) mounting height~~
2. ~~360 degrees x 70 ft (20 m) diameter pattern~~
3. ~~Fully adjustable optical arrays for coverage customization~~
4. ~~Rated for use in difficult environment to reduce false alarms from background disturbances such as air movement and hanging signs.~~
5. ~~Combination of passive infrared (PIR) detection, microwave detection, and advanced signal processing technology.~~
6. ~~Built in tamper switch~~
7. ~~Operating Temperature: 40 to 120 deg F (40 to 49 deg C)~~
8. ~~Dimensions: 3.5 x 7 in (8.9 x 17.8 cm)~~
9. ~~Voltage: 9 to 15 VDC~~
10. ~~UL Listed~~

2.3 ~~DIRECTIONAL DUAL TECH MOTION SENSOR~~

A. ~~Acceptable Manufacturers~~

1. ~~Bosch~~
2. ~~Approved Equivalent~~

B. ~~Bosch ISC CDL1 WA15G or approved equivalent~~

C. ~~Minimum Features and specifications~~

1. ~~Combination of passive infrared (PIR) detection, microwave detection, and advanced signal processing technology.~~
2. ~~Active infrared ant masking~~
3. ~~Microwave noise adaptive processing~~
4. ~~Mounting height: 7.5 x 9 ft (2.3 x 2.75 m)~~
5. ~~Coverage Pattern: 50 x 50 ft (15 x 15 m)~~
6. ~~Built in tamper switch~~

- 7. — Operating Temperature: 32 to 120 deg F (0 to 49 deg C)
- 8. — Dimensions: 4.7 x 2.75 x 2.2 in (12 x 7 x 5.5 cm)
- 9. — Voltage: 9 to 15 VDC
- 10. — UL Listed

2.4 — CURTAIN PIR MOTION SENSOR

A. — Acceptable Manufacturers

- 1. — Honeywell
- 2. — Approved Equivalent

B. — Honeywell IS216T-CUR or approved equivalent

C. — Minimum Features and specifications

- 1. — Dual element passive infrared
- 2. — Mounting height: 5 x 8.8 ft (1.5 x 2.7 m)
- 3. — 32 ft (10 m) in vertical mount position
- 4. — Operating temperature: 14 to 131 deg F (-10 to 55 deg C)
- 5. — Dimensions: 3.4 x 2.4 x 1.5 in (8.6 x 6 x 3.8 cm)
- 6. — Supply Voltage: 8.5 to 15.4 VDC (12 VDC nominal)

2.5 — LONG-RANGE DUAL TECH MOTION SENSOR

A. — Acceptable Manufacturers

- 1. — Honeywell
- 2. — Approved Equivalent

B. — Honeywell [DT900 / DT901] [DT906 / DT907] or approved equivalent

C. — Minimum Features and specifications

- 1. — Combination of passive infrared (PIR) detection, microwave detection, and advanced signal processing technology.
- 2. — Mounting height: 2 to 3.7 m (6 to 12 ft)
- 3. — Coverage Pattern:
 - a. — [DT900/901: 50 x 40 ft (15 x 12 m), and 90 x 70 ft (27 x 21 m)]
 - b. — [DT906/907: 120 x 10 ft (37 x 3 m), and 200 x 15 ft (61 x 5 m)]
- 4. — Built in housing tamper switch
- 5. — [[DT900] [DT906]: Anti masking using active infrared look-down lens]
- 6. — [[DT900] [DT906]: Detector mount tamper switches (2)]
- 7. — Operating Temperature: 32 to 120 deg F (0 to 49 deg C)
- 8. — Dimensions: 8 x 6.5 x 6 in (20 x 17 x 15 cm)
- 9. — Voltage: 10 VDC to 15 VDC, 12 VDC nominal
- 10. — UL Listed

2.6 ~~LONG RANGE PIR~~

A. ~~Acceptable Manufacturers~~

- ~~1. Bosch~~
- ~~2. Approved Equivalent~~

B. ~~Bosch DS778 Long Range PIR Detector or approved equivalent~~

C. ~~Minimum Features and specifications~~

- ~~1. Mounting height: 6.5 x 8.5 ft (2 x 2.6 m)~~
- ~~2. Coverage: 200 x 15 ft (60 x 4.5 m)~~
- ~~3. Built in tamper switch~~
- ~~4. Operating Temperature: 40 to 120 deg F (-40 to 49 deg C)~~
- ~~5. Dimensions: 5.75 x 3.75 x 2.5 in (14.6 x 9.5 x 6.35 cm)~~
- ~~6. Voltage: 6 to 15 VDC~~
- ~~7. UL Listed~~

2.7 ~~GLASS BREAK DETECTOR, ACOUSTIC~~

A. ~~Acceptable Manufacturers~~

- ~~1. Honeywell~~
- ~~2. Approved Equivalent~~

B. ~~Honeywell FG 730 or approved equivalent~~

C. ~~Minimum Features and specifications~~

- ~~1. Analysis of both impact and shattering frequencies~~
- ~~2. Signal verification~~
- ~~3. Coverage: 30 ft (90 m); minimum glass size: 11 x 11 in (27.9 x 27.9 cm)~~
- ~~4. Operating temperature: 32 to 120 deg F (0 to 49 deg C)~~
- ~~5. Supply Voltage: 10 to 14VDC (12 VDC nominal)~~
- ~~6. Mounting locations: Ceiling, opposite wall, adjoining wall, same wall as glass~~

2.8 ~~DOOR POSITION SWITCH; RECESSED~~

A. ~~Acceptable Manufacturers~~

- ~~1. Magnasphere~~
- ~~2. Approved Equivalent~~

B. ~~Magnasphere MSS-20 Series, MSS-26 Series for Normally Closed Loop or approved equivalent~~

C. ~~Minimum Features and Specifications~~

- ~~1. UL 634 Listed~~

2. Recessed
3. Magnetic tamper
4. 0.75 in (19 mm) or 1 in (25.4 mm) diameter
5. Capable of operating with a 0.5 in (13 mm) gap
6. Screw Terminals or 12 in (305 mm) wire leads, #22 AWG, solid

2.9 DOOR POSITION SWITCH; SURFACE

A. Acceptable Manufacturers

1. Magnasphere
2. Approved Equivalent

B. Magnasphere MSS-30XS Series or approved equivalent

C. Minimum Features and Specifications

1. UL 634 Listed
2. Surface mounted
3. Magnetic tamper
4. Size: 2 x 0.5 x 1 in (51 x 12.7 x 25.4 mm).
5. Capable of operating with a 0.3 in (7.6 mm) gap
6. Armored cable lead 24 in (61 mm)
7. Only for use on hatches where a standard recessed contact cannot be used

2.10 DOOR POSITION SWITCH; OVERHEAD

A. Acceptable Manufacturers

1. Magnasphere
2. Approved Equivalent

B. Magnasphere MSS-105S or approved equivalent

C. Minimum Features and Specifications

1. UL 634 listed
2. Surface Mounted with overhead door bracket
3. Capable of operating with a 0.5 inch gap
4. Magnetic tamper
5. 5 ft (1.5 m) leads

2.11 DOOR POSITION SWITCH, UL LEVEL 1, SURFACE

A. Acceptable Manufacturers

1. Magnasphere
2. Approved Equivalent

B. Magnasphere HS-L1.5 Series or approved equivalent

C. Minimum Features and Specifications

1. UL 634, Level 1 high security (both in-swing and out-swing doors)
2. Surface mounted
3. External and internal magnetic tamper
4. Size: 4.25 x 1 x 1 in (108 x 25.4 x 25.4 mm).
5. Capable of operating with a 0.25 in (6.35 mm) gap
6. Wire leads, #22 AWG, solid, in 18 in (457 mm) armored cable
7. Housing: Aluminum case, silver-gray anodized
8. Dual alarm contacts – Use for both IDS and ACS (two closed loop or one closed loop / one open loop)
9. NO adjustment required for installation
10. NO brackets needed for most out-swing door installations
11. Integrated removal / pry tamper (no back plates)

2.12 DOOR POSITION SWITCH; HIGH SECURITY, RECESSED

A. Acceptable Manufacturers

1. Magnasphere
2. Approved Equivalent

B. Magnasphere HSS-L2C or HSS-L2C-A or approved equivalent

C. Minimum Features and Specifications

1. UL 634 Level 2 High Security Listed
2. Recessed
3. Integrated Removal Tamper Circuit and hardware, to actuate on removal of switch from mounting surface
4. Used with, or contain embedded End of Line (EOL) resistors compatible with Software House control panels
6. Rated for both indoor and outdoor use
7. Qualify as an Intrinsically Safe - Simple Apparatus.
8. Installable in either a 1 in (25.4 mm) diameter hole or standard ANSI door cutout
9. Capable of operating with a 0.0625 in (1.5875 mm) gap
10. Wire leads, #22 AWG, solid, 12 in (305 mm) length
11. Brass magnet housing, ABS switch housing

2.13 DOOR POSITION SWITCH; HIGH SECURITY SURFACE

A. Acceptable Manufacturers

1. Magnasphere
2. Approved Equivalent

B. Magnasphere HSS-L2S Series or approved equivalent

C. Minimum Features and Specifications

1. UL 634, Level 2 listed
2. Surface mounted
3. Integrated Removal Tamper Circuit and hardware, to actuate on removal of
4. switch from mounting surface
5. Used with, or contain embedded End of Line (EOL) resistors compatible with Software House control panels
6. Rated for both indoor and outdoor use
7. Qualify as an Intrinsically Safe - Simple Apparatus.
8. Size: 4.25 x 1.5 x 1 in (108 x 38 x 25.4 mm).
9. Capable of operating with a 0.125 in (3.18 mm) gap
10. Wire leads, #22 AWG, solid, in 36 in (91.4 cm) armored cable
11. Housing: Aluminum case, silver-gray anodized

D. Additional Required Options / Parts

1. HSS Roll-up Door Bracket Kit for use on overhead doors

2.14 — VIBRATION DETECTOR~~A. — Acceptable Manufacturers~~

- ~~1. — Bosch~~
- ~~2. — Approved Equivalent~~

~~B. — Bosch ISN SM 80, or approved equivalent.~~~~C. — Minimum Features and Specifications~~

- ~~1. — 5 m operating radius on concrete~~
- ~~2. — Dimensions: 3.5 x 3.5 x .86 in (8.9 x 8.9 x 2.2 cm)~~
- ~~3. — Operating temperature: 40 to 158 deg F (40 to 70 deg C)~~
- ~~4. — Supply Voltage: 8 to 16 VDC (12 VDC nominal)~~

2.15 — VIBRATION DETECTOR, SOLID STATE~~A. — Acceptable Manufacturers~~

- ~~1. — George Risk Industries, Inc.~~
- ~~2. — Approved Equivalent~~

~~B. — GRI Shockgard 2 SG 2 or approved equivalent.~~~~C. — Minimum Features and Specifications~~

- ~~1. — 12 in (30.5 cm) operating radius on steel~~
- ~~2. — Dimensions: .91 x .98 x 3.4 in (2.3 x 2.5 x 8.6 cm)~~
- ~~3. — Operating temperature: 4 to 140 deg F (- 20 to 60 deg C)~~

4. ~~Supply Voltage: 9 to 15 VDC, Regulated~~

2.16 ~~WIRELESS RECEIVER~~

A. ~~Acceptable Manufacturers~~

1. ~~Inovonics~~
2. ~~Approved Equivalent~~

B. ~~Inovonics EN7283 Serial or approved equivalent~~

C. ~~Minimum Features and Specifications~~

1. ~~Operating Frequency: 900MHz~~
2. ~~Dimensions: 6.3 x 3.5 x 1.0 in (16 x 8.9 x 2.5 cm)~~
3. ~~Housing Material: ABS plastic~~
4. ~~Power: 12 VDC from the security power supply with minimum eight (8) hours of back-up battery~~

2.17 ~~WIRELESS REPEATER~~

A. ~~Acceptable Manufacturers~~

1. ~~Inovonics~~
2. ~~Approved Equivalent~~

B. ~~Inovonics EN5040T or approved equivalent~~

C. ~~Minimum Features and Specifications~~

1. ~~Operating Frequency: 900MHz~~
2. ~~Dimensions: 6.3 x 3.5 x 1.0 in (16 x 8.9 x 2.5 cm)~~
3. ~~Housing Material: ABS plastic~~
4. ~~Power: 12-16.5 VAC or VDC via manufacturer's transformer~~
5. ~~Battery Capacity: 2450mAh @ 3.7V~~
6. ~~Back up battery life: Up to 24 hours (varies with repeater use)~~

2.18 ~~WIRELESS TRANSMITTER~~

A. ~~Acceptable Manufacturers~~

1. ~~Inovonics~~
2. ~~Approved Equivalent~~

B. ~~Inovonics EN1210 or approved equivalent~~

C. ~~Minimum Features and Specifications~~

1. ~~Fully Supervised with case tamper~~
2. ~~Operating Frequency: 900MHz~~
3. ~~Dimensions: 3.5 x 1.7 x 0.9 in (8.9 x 4.3 x 2.3 cm)~~
4. ~~Housing Material: ABS plastic~~
5. ~~Battery Life: 4-5 years~~

2.19 ~~RECESSED ROLLER PLUNGER~~

A. ~~Acceptable Manufacturers~~

1. ~~GE Interlogix~~
2. ~~Approved Equivalent~~

B. ~~GE Interlogix 3008 or approved equivalent~~

C. ~~Minimum Features and Specifications~~

1. ~~Recessed magnetic contact~~
2. ~~Housing: .75 in (1.9 cm) diameter, .75 in (1.9 cm) depth~~
3. ~~Flame retardant ABS~~
4. ~~Roller travel: .25 in (.63 cm)~~
5. ~~Activation: .0625 in (.16 cm), minimum~~

2.20 ~~ELECTRONIC SHOCK SENSOR~~

A. ~~Acceptable Manufacturers~~

1. ~~George Risk Industries (GR2)~~
2. ~~Approved Equivalent~~

B. ~~GRI SG 2 or approved equivalent~~

C. ~~Minimum Features and Specifications~~

1. ~~On-board tamper switch~~
2. ~~Solid state piezo electric sensor~~
3. ~~Housing: .5 in (1.3 cm) diameter~~
4. ~~Flame retardant ABS~~
5. ~~No processor unit required~~
6. ~~Size: 3.4 x 0.9 x 1.0 in (8.6 x 2.3 x 2.5 cm)~~

PART 3 - EXECUTION

3.1 GROUNDING

- A. Comply with requirements in Section 270526.10 "Grounding and Bonding for Security Systems" for grounding conductors and connectors.

3.2 SYSTEM INTEGRATION

- A. Integrate intrusion detection system with the following systems and equipment:
 - 1. Electronic door hardware – locking/unlocking, request-to-exit
 - 2. Elevators – none
 - 3. Network lighting controls – none
 - 4. Intercommunications and program systems – none
 - 5. Public address and mass notification systems – none
 - 6. Access control – door contacts and IDS zones
 - 7. Fire-alarm system – none
 - 8. Perimeter security system – none
 - 9. Video surveillance – video call-up of appropriate camera(s) for each alarm activation

3.3 SYSTEM INSTALLATION

- A. Comply with UL 681 and NFPA 731.

3.4 GENERAL

- A. Supervision
 - 1. Configure system components to continuously monitor for normal, alarm, line supervision, tamper, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 - 2. Trouble Condition Signal: Indicates the system is not fully functional (e.g. sensor battery failure, open or shorted/grounded transmission line conductors, or device cover removed).

3.5 REFER TO 280500.10 FOR ALL OTHER PART III REQUIREMENTS

END OF SECTION 283100

SECTION 28 3111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM**PART 1 - GENERAL****1.1 SUMMARY**

- A. This work includes designing and providing a new, completely supervised, multiplexed, addressable, intelligent, analog fire alarm system (devices, components and wiring) as described herein and on the contract drawings for the Project.
1. Include all wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment, alarm, and supervisory signal initiating devices, alarm notification appliances, software and programming, acceptance testing and all other accessories and miscellaneous items required for a complete operating system even though each item is not specifically mentioned or described. Provide equipment with components identical to and bearing the labeling of those approved for intended use by independent testing laboratory.
- B. Section Includes:
1. Fire-alarm control unit.
 2. Manual fire-alarm boxes.
 3. System smoke detectors.
 4. Notification appliances.
 5. Firefighters' smoke-control station.
 6. Remote annunciator.
 7. Addressable interface device.
 8. Digital alarm communicator transmitter.
 9. Notification appliance circuit power extender panel (NAC).
 10. Network communications.
- C. Related Requirements:
1. Section 01 3573 "Delegated Design Requirements and Procedures" for definitions, submittal procedures, responsibilities, and scheduling requirements associated with delegated design assignment indicated in this Section.
 2. Division 07 Section "Penetration Firestopping • • " for fire stopping requirements not in this Section.
 3. Provisions of Division 26 Sections "Common Work Results for Electrical • • " and "Raceways and Boxes for Electrical Systems • • " apply to this Section.
 4. Section 28 0513 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.2 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

- F. VESDA: Very Early Smoke-Detection Apparatus.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.
1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 2. Include plans, elevations, sections, details, and attachments to other work.
 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
 4. Detail assembly and support requirements.
 5. Include voltage drop calculations for notification-appliance circuits.
 6. Include battery-size calculations.
 7. Include input/output matrix.
 8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
 9. Include performance parameters and installation details for each detector.
 10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
 12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
 - c. Locate detectors according to manufacturer's written recommendations.
 13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
 14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
- C. General Submittal Requirements:
1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
 2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.
- D. Delegated-Design Submittal: Refer to Section 01 3573 "Delegated Design Requirements and Procedures" for delegated design submittal procedures and requirements.

1. Provide delegated design submittal for notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria.
 - a. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
 - b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
 - c. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:
 - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.
 - e. Device addresses.
 - f. Record copy of site-specific software.
 - g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.

- 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
- 3. Device address list.
- 4. Printout of software application and graphic screens.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
- 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
- 3. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
- 4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
- 5. Keys and Tools: One extra set for access to locked or tamperproofed components.
- 6. Visual Notification Appliances: One of each type installed.
- 7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Installer Qualifications: Installation shall be by personnel certified by NICET as minimum fire-alarm Level III technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).
- D. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.
- E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of existing <Insert Manufacturer's name> system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as a system.
- B. Noncoded, UL-certified [**FM Global-placarded**] addressable system, with multiplexed signal transmission and [**voice**][**horn**]/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 - 1. Manual stations.
 - 2. Smoke detectors.
 - 3. Automatic sprinkler system water flow.
- B. Fire-alarm signal shall initiate the following actions:
 - 1. Continuously operate alarm notification appliances.
 - 2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
 - 3. Transmit an alarm signal to the remote alarm receiving station.
 - 4. Unlock electric door locks in designated egress paths.
 - 5. Release fire and smoke doors held open by magnetic door holders.
 - 6. Activate voice/alarm communication system.
 - 7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 - 8. Activate smoke-control system (smoke management) at firefighters' smoke-control system panel.
 - 9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 10. Activate emergency lighting control.
 - 11. Activate emergency shutoffs for gas and fuel supplies.
 - 12. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
 - 1. Valve supervisory switch.
 - 2. Independent fire-detection and -suppression systems.
 - 3. User disabling of zones or individual devices.
 - 4. Loss of communication with any panel on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
 - 1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. Record the event on system printer.
4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
5. Transmit system status to building management system.
6. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a registered design professional, as defined in Section 01 3573 "Delegated Design Requirements and Procedures" to design notification appliances, and smoke and heat detectors.
1. Material properties indicated in this Section shall be considered as minimum properties.

2.4 FIRE-ALARM CONTROL UNIT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Fire-Lite Alarms.
 2. Notifier.
 3. Siemens Industry, Inc.; Fire Safety Division.
- B. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
 - d. The FACP shall be listed for connection to a central-station signaling system service.

- e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
 - 2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
 - 3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - 1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
 - 1. Pathway Class Designations: NFPA 72, Class B.
 - 2. Pathway Survivability: Level 1.
 - 3. Install no more than 50 addressable devices on each signaling-line circuit.
 - 4. Serial Interfaces:
 - a. One dedicated RS 485 port for central-station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
 - c. One USB port for PC configuration.
 - d. One RS 232 port for VESDA HLI connection.
 - e. One RS 232 port for voice evacuation interface.
- E. Notification-Appliance Circuit:
 - 1. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- F. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall [be] [not be] connected to fire-alarm system.
- G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

- I. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- J. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 - 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- K. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
 - 1. Batteries: Sealed lead calcium.
- L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 MANUAL FIRE-ALARM BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fire-Lite Alarms.
 - 2. Notifier.
 - 3. Siemens Industry, Inc.; Fire Safety Division.
- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 - 2. Station Reset: Key- or wrench-operated switch.
 - 3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
 - 4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fire-Lite Alarms.
 - 2. Notifier.

3. Siemens Industry, Inc.; Fire Safety Division.
- B. General Requirements for System Smoke Detectors:
1. Comply with UL 268; operating at 24-V dc, nominal.
 2. Detectors shall be four -wire type.
 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 5. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition.
 - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
 - b. Multiple levels of detection sensitivity for each sensor.
 - c. Sensitivity levels based on time of day.
- C. Photoelectric Smoke Detectors:
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
- D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
 3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
 4. Each sensor shall have multiple levels of detection sensitivity.
 5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 NOTIFICATION APPLIANCES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Wheelock.
 - 2. Federal Signal Corporation.
 - 3. GE UTC Fire & Security; A United Technologies Company.
 - 4. Gentex Corporation.
 - 5. Siemens Industry, Inc.; Fire Safety Division.
 - 6. SimplexGrinnell LP.
 - 7. System Sensor.
- B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
 - 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 - 2. Mounting: Wall mounted unless otherwise indicated.
 - 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 - 4. Flashing shall be in a temporal pattern, synchronized with other units.
 - 5. Strobe Leads: Factory connected to screw terminals.
 - 6. Mounting Faceplate: Factory finished, white.

2.8 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 - 1. Mounting: Surface cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.9 ADDRESSABLE INTERFACE DEVICE

- A. General:
 - 1. Include address-setting means on the module.
 - 2. Store an internal identifying code for control panel use to identify the module type.
 - 3. Listed for controlling HVAC fan motor controllers, fire pumps, and emergency generators for monitoring status
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

- C. Control Module:
 - 1. Operate notification devices.
 - 2. Operate solenoids for use in sprinkler service.

2.10 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address of the trouble-initiating device.
 - 4. Loss of ac supply.
 - 5. Loss of power.
 - 6. Low battery.
 - 7. Abnormal test signal.
 - 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ELECTRIC POWER

- A. Provide primary power for all fire alarm panel equipment from the emergency AC service to the building where shown on the drawings. Power shall be 120 VAC service, transformed through a two-winding, isolation type transformer and rectified to low voltage DC for operation of all circuits and devices. Make the service connection for the fire alarm panel equipment at the junction box labeled "FACP Connection" connected to the emergency distribution panel where shown. The circuit breaker shall be painted red, marked "Fire Alarm Control Circuit" and shall be provided with a lockable handle or cover. All 120 VAC primary power circuits shall be equipped with surge protection devices (SPD).

3.3 SYSTEM FIELD WIRING

- A. Wiring within Cabinets, Enclosures, Boxes, Junction Boxes and Fittings:
 - 1. Provide wiring installed in a neat and workmanlike manner and installed parallel with or at right angles to the sides and back of any box, enclosure or cabinet.
 - 2. Connect conductors which are terminated, spliced, or otherwise interrupted in any enclosure, cabinet, mounting or junction box, to terminal blocks.
 - 3. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved pressure type terminal blocks, which are securely mounted.
 - 4. Wire nuts and similar devices are not acceptable.
- B. Provide a terminal cabinet where indicated on the Drawings.
 - 1. Use terminal sizes appropriate for the size of the wiring to be connected.
 - 2. Provide labeling of conductor terminations, and a diagram permanently mounted in the terminal cabinet, showing all conductors, their labels, their circuits and their interconnection.
 - 3. Provide terminal cabinets having 25 percent spare backbox space.
- C. Fire Alarm Wiring:
 - 1. Provide fire alarm circuits in accordance with the equipment manufacturer's requirements, NFPA 70 – National Electrical Code, specifically Article 760 and these Specifications. Provide wire size sufficient to prevent voltage drop problems.
 - 2. Circuits operating at 24 VDC shall not operate at less than 21.6 volts.
 - 3. Audio speaker circuits operating at 70.7 VRMS shall be designated to operate at less than 0.5 dB (12.5 percent) loss. Circuits operating at any other voltage shall not have a voltage drop exceeding 10 percent of nominal voltage.
 - 4. Install all conductors in minimum electrical-metallic tubing (EMT), with a minimum diameter of 3/4 inch.
 - 5. Use shielded wiring where recommended by the manufacturer. For shielded wiring, the shield shall be grounded at only one point, which shall be in or adjacent to the FACP. Treat the drain or shield wires as a fire alarm conductor, landed on terminal strips. The drain wire shall be sleeved or insulated to within 1 inch of its termination. T-taps are not permitted. Circuits to fan shutdown systems shall terminate in terminal cabinets within 3 feet of the controllers for those systems

D. Wiring Installation:

1. All alarm initiating devices and supervisory initiating devices shall be connected on Style 4 two (2) wire (Class B) Signaling Line Circuits (SLC). Unsupervised wiring (point wires) shall not be permitted. Parallel branch circuit wiring shall be permitted on the addressable SLCs.
2. All alarm indicating devices shall be connected on Style Y two (2) wire electrically supervised circuits and on a minimum of two active circuits.
3. Wiring to initiating and supervisory devices and to fire alarm annunciators shall be with two (2) conductor twisted size 16 solid copper UL listed fire alarm system wire, subject to manufacturer's recommendations.
4. Wiring to alarm indicating devices shall be with two (2) conductors twisted No. 14 AWG solid copper UL listed jacketed fire alarm system wire, subject to manufacturer's recommendations.
5. Power wiring, operating at 120 VAC minimum, shall be No. 12 AWG solid copper, 600 VAC rated THHN/THWN insulation.
6. All other wiring shall be solid copper No. 14 AWG minimum with 600 volt THHN insulation except as specifically noted.
7. No splicing of wires is permitted except on terminal blocks in annunciators, control panels or properly labeled terminal cabinets as shown on the drawings.
8. The use of wire nuts or similar type devices is not permitted.

E. Conductor Terminations:

1. All devices shall have terminals for each wiring connection.
2. No splicing of any type shall be permitted in pull boxes, to include crimp terminals.
3. No specific color coding is required for any circuit; however, labeling of any circuit at terminal blocks in terminal cabinets, FACP, and remote fire alarm control units shall be provided at each conductor connection.
4. Each conductor or cable shall have a permanent label to provide a unique and specific designation.
5. Each terminal cabinet, FACP and remote fire alarm control unit shall contain a laminated drawing which indicates each conductor, its label, circuit and terminal. The laminated drawing shall be neat, using 12 point lettering minimum size, and mounted within each cabinet, panel or unit so that it does not interfere with the wiring or terminals.
6. All wires shall be labeled at both ends.. Use plastic wire ties and wire tie mounts to ensure a neat quality appearance.

F. Conduit Installation:

1. Conceal all electrical conduits above suspended ceilings and behind walls, except in unfinished areas where conduit may be surface mounted, unless otherwise specified.
2. The use of metal clad (MC) cable is acceptable only in concealed spaces and only as allowed by other Codes, including channeled walls and above suspended ceilings. The MC Cable shall be installed and supported in accordance with NFPA 70-NEC.
3. MC cable is not acceptable for smoke control system wiring.
4. All exposed conduit shall be painted to match adjacent finish.

G. Conduit Size:

1. Both exposed and concealed conduit including risers up to 2 inches in diameter shall utilize compression type steel fittings and connectors.
2. Unless otherwise noted, all conduit provided shall be 3/4 inch minimum trade size.
3. Vertical risers shall be one inch diameter minimum.

4. Limited use of 1/2 inch conduit is permitted on horizontal runs when a reduced diameter is required for better concealment. Where necessary, 1/2 inch diameter flex conduit may be fished or used for concealed work. Provide plenum rated wiring conductors (Type FPLP) when flex conduit is used.

3.4 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.
 1. Comply with requirements for seismic-restraint devices specified in Section 26 0548.16 "Seismic Controls for Electrical Systems."
- C. Manual Fire-Alarm Boxes:
 1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
 2. Mount manual fire-alarm box on a background of a contrasting color.
 3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- D. Smoke- or Heat-Detector Spacing:
 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing shall not exceed 30 feet (9 m) .
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A [or Annex B]in NFPA 72.
 5. HVAC: Locate detectors not closer than 36 inches (910 mm) from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.
 1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

- G. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- H. Visible Alarm-Indicating Devices: Install weather-proof device at exterior fire department connection. Locate in accordance with local authority having jurisdiction.
- I. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.5 PATHWAYS

- A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.
 - 1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.
- B. Pathways shall be installed in EMT.
- C. Exposed EMT shall be painted red enamel.

3.6 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 08 7100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
 - 2. Smoke dampers in air ducts of designated HVAC duct systems.
 - 3. Magnetically held-open doors.
 - 4. Electronically locked doors and access gates.
 - 5. Alarm-initiating connection to activate emergency lighting control.
 - 6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 - 7. Supervisory connections at valve supervisory switches.
 - 8. Data communication circuits for connection to building management system.
 - 9. Supervisory connections at fire-extinguisher locations.

3.7 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.8 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.9 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Perform the following tests and inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

- I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.10 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.11 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within [two] years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION

SECTION 31 1000 – SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Sections includes the following:
 - 1. Protecting existing vegetation to remain.
 - 2. Removing existing below-grade site improvements.
 - 3. Disconnecting, capping or sealing, and removing or abandoning site utilities.
 - 4. Providing temporary erosion- and sedimentation-control measures.

1.2 REFERENCES

- A. DOE – Department of Energy and Environment.

1.3 DEFINITIONS

- A. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project Site.

1.5 SUBMITTALS

- A. Photographs or videotapes, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

1.6 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining walks and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct walks or other adjacent occupied or used facilities without permission from Owner and Contracting Officer Technical Representative (COTR).
 - 2. Provide alternative routes around closed or obstructed traffic ways if required by COTR.
- B. Utility Locator Service: Notify utility locator service for area where project is located before site clearing.
- C. Do not commence site clearing operations until temporary erosion and sediment control measures are in place.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly flag trees and vegetation to remain. Erect a 6-foot high chain link tree protection fence as close to the critical root zone as possible.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to the Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to the erosion and sediment control plans, and in accordance with DOEE Standards and Specifications for Soil Erosion and Sediment Control.
- B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- C. Remove erosion and sedimentation controls after areas disturbed during construction are restored and stabilized.

3.3 UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by contractor.
 - 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
 - 1. Arrange with utility companies to shut off indicated utilities.
 - 2. Owner will arrange to shut off indicated utilities when requested by Contractor.
- C. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.
 - 1. Notify Owner no less than three days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's written permission.
- D. Excavate for and remove underground utilities indicated to be removed.

3.4 DISPOSAL

- A. Disposal: Remove demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's Property.

June 15, 2026

Smithsonian OPDC Project No. 2533105

SmithGroup Project No. 00100084

1. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION

FOR REFERENCE ONLY

SECTION 312300 - EARTHWORK

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS

- A. Provide all facilities, labor, materials, equipment, transportation, supervision, and related work necessary to complete the Work specified in this Section, and as shown on the Drawings.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section. All work under this Section of the Specifications shall be performed in accordance with Division 01 (General Requirements).
- C. Coordinate work with that of all other trades affecting or affected by the Work of this Section. Cooperate with such trades to ensure the steady progress of all work under the Contract.
- D. All work shall be performed in accordance with applicable codes, permits and regulations, and the requirements of all local, state, and federal agencies having jurisdiction over the work.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.3 DESCRIPTION OF WORK

- A. The Work of this Section includes, but is not limited to:
 - 1. Excavating all types of materials (e.g., soil, boulders, bedrock, utilities, foundations, pavements, debris) to limits and bottom of excavation elevations indicated on the Drawings and herein, or required for foundations, slabs, utilities and other site improvements shown on the Drawings.
 - 2. Over-excavate soil and weathered rock, and other unsuitable materials to suitable foundation bearing strata.
 - 3. Preparing bearing surfaces for foundations.
 - 4. Installing building foundation drainage systems as shown on the Drawings.
 - 5. Providing, placing, moisture conditioning, compacting, and grading of fill and backfill materials to the specified limits and percent compaction required to construct foundations, slabs, structures, utilities, roadways, parking areas, walkways, landscaped areas, and other site improvements shown on the Drawings.
 - 6. Handling, conveying, segregating, and stockpiling materials used during the course of the Work.
 - 7. Re-use of the on-site soils to the extent possible.
 - 8. Removing from the site and legally disposing of excess materials and materials that are not suitable for on-site re-use in accordance with the Specifications.
 - 9. Removing from the site and legally and temporarily stockpiling materials that are suitable and planned for on-site re-use in accordance with the Specifications.
 - 10. Protecting existing utilities, structures, and other facilities to remain during the work.

11. Preventing trafficking of soil materials onto public roads or sidewalks and providing street cleaning to remove such materials during the work.
12. Obtaining, paying for, and complying with all required permits, licenses, and approvals prior to commencing the work.

1.4 RELATED SECTIONS

- A. Related Sections
 1. 024119 Selective Demolition
 2. 033000 Cast-in-Place Concrete
 3. 221313 Facility Sanitary Sewers
 4. 311000 Site Clearing
 5. 316333 Micropiles
 6. 321313 Concrete Paving
 7. 331415 Site Water Distribution Piping
 8. 334200 Stormwater Conveyance

1.5 DEFINITIONS

- A. Refer to Section 011000 for definition of Owner, Architect, Construction Manager, Owner's Representative, and Contractor. In this Section the term Contractor may refer to the Construction Manager as Constructor or Construction Contractor.
- B. Bidder: Entity bidding to complete the Work of this Section. After award of the contract, the Bidder becomes the Contractor for the purposes of this Section.
- C. Site: Refer to the limits of construction shown on the Drawings.
- D. Site Improvements: shall include, but not be limited to, buildings, structures, foundations, underground and above-ground utilities, pavements, landscaping, plants, slabs, sidewalks, curbs, and all other site features that are outside the limits of the site, and/or those elements within the limits of the site that are to remain.
- E. Exploration: shall include, but not be limited to, test borings and test pits and results of field and lab testing.
- F. Building Code or Code: Refer to the standards and regulations indicated on the Drawings.
- G. Rock (Bedrock): Mass of naturally formed, crystalline-mineral material that is hardened and intact or with in-situ discontinuities, and may be altered by weathering up to the degree it is soil-like.
- H. Structures: Foundations, slabs, walls, equipment pads, tanks, mechanical, plumbing, and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, or the vertical excavation level and slopes indicated on the Drawings to which the excavation shall be conducted. For footing bearing subgrades this level

will be to the elevations indicated on the Drawings, or the top of material in a state suitable for foundation bearing, whichever is lower.

- J. Trench: Excavation of any length where width at top is less than twice the depth and depth is greater than 5 ft.
- K. Zone(s) of Influence (ZOI): The zone(s) below lines extending away from a structural element (e.g., spread footing foundation, slab-on-grade, pile cap) shown on the Drawings. The lines for the element are:
 - 1. At a slope of one and one-half horizontal to one vertical (1.5H:1V) beginning at the bottom outside edge of the element and away from the element until intersecting suitable bearing materials.
 - 2. Horizontal beginning at the 1 ft above the top of a laterally loaded element and extending away for a distance of three times the element height.

1.6 PROJECT CONDITIONS

- A. Prior to submitting a bid, the Bidder shall review and understand the information contained in the following documents. These documents are made available to the Bidder for informational purposes only. The subsurface conditions information presented in these documents, as applicable, are for informational purposes only and shall not be interpreted as a warranty of subsurface conditions whether interpreted from written text, exploration results, laboratory results, or other data or interpretations of data.
 - 1. "Report on Geotechnical Engineering Study, Construct Arabian Leopard Habitat, National Zoological Park, 3100 Connecticut Avenue NW, Washington, DC" prepared by Haley & Aldrich, Inc., dated March 2026.
- B. Prior to submitting a bid, the Bidder shall examine the records of subsurface features including but not limited to utilities and foundations, records of explorations, and the exploration samples to determine conditions under which the Work will be performed. The exploration samples are available for review at Haley & Aldrich, Inc., Vienna, Virginia.
- C. The exploration information represents subsurface conditions at the exploration locations at the time conducted. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between explorations. It is expressly understood that the Owner and Architect will not be responsible for interpretations or conclusions drawn there from by the Bidder.
- D. The Contractor may perform additional explorations and laboratory testing or field screening for their own information at no cost to the Owner following approval in writing from the Owner. The Bidder shall include the cost of any additional studies it deems necessary to properly perform the Work specified in this Section, in the Related Sections, and as shown on the Drawings.
- E. If, during the course of construction operations, conditions differing substantially from those indicated in the documents referenced in this Section are encountered, promptly notify the Owner's Representative and Architect in writing, and do not disturb such conditions until directed. The Owner, Owner's Representative, and Architect will investigate such conditions,

and, if it is determined that the conditions differ substantially from those that reasonably would have been anticipated from examination of the subsurface information and site, and that such conditions will necessitate a change in the Work, the Architect will recommend any required changes and adjustments in writing. Oral or written communications with field personnel shall not constitute acknowledgment of a differing subsurface condition.

1.7 QUALITY ASSURANCE AND CONTROL

- A. The Contractor shall perform on-site observation and testing during various phases of the construction operations. The presence of the Owner's Representative or Architect does not constitute supervision or direction of the Contractor's work. Neither the presence of the Owner's Representative or Architect, nor any observations and testing performed by them, nor any notice or failure to give notice shall excuse the Contractor from conformance with these Specifications or from defects discovered in his work or from the Contractor's responsibility for site safety including both persons and property.
- B. The Contractor shall conduct various laboratory and field testing and interpret the results to assess conformance with the requirements of the Contract Documents for the work of this Section and related sections. Except as indicated in the Contract Documents, the Contractor shall determine the types and frequency of testing as may be appropriate in coordination with the Owner's Representative. The Contractor will prepare a report indicating non-conformances as determined by the testing.
- C. Subgrades and fill layers shall be tested (if applicable), observed as required, and accepted by the Owner's Representative before construction of any further work thereon.
 - 1. The Owner's Representative and Architect may perform observation and field testing at any point during the work. Cooperate with the Owner's Representative and Architect to obtain field samples and conduct field testing. Furnish incidental labor in connection with the required sampling and testing.
 - 2. The Contractor shall be responsible for notifying the Owner's Representative and Architect of upcoming earthwork activities by providing a weekly schedule of work activities at least two business days prior to the start of each week, and with 24 hours prior notice, daily changes to the schedule.
 - 3. If, based on the observation and/or testing by the Contractor, a subgrade or backfill non-conformance is found (e.g., backfill below specified density), the non-conformance shall be remediated by the Contractor. All costs related to testing or remediation/replacement of nonconforming work/materials shall be paid for by the Contractor at no additional cost to the Owner and with no schedule impact to the Project.
 - 4. No fill material shall be removed from the site or delivered to the site prior to written acceptance by the Architect. Off-site materials, which are not accepted, if brought to the site, shall be immediately removed by the Contractor at no cost to the Owner.
 - 5. All materials being imported to the site shall be newly-excavated materials, free from contamination, oil and hazardous materials.
 - 6. The Contractor shall conduct its Work in a manner so that vibrations of buildings, structures, ground surfaces, site features, and utilities outside of the limits of Work do not exceed the more restrictive of 0.5 inches per second at all times or requirements provided by the Owner.

1.8 SUBMITTALS

- A. The Contractor shall submit the following for review.
1. A narrative and drawings (plans and sections) and calculations, describing the following: schedule, sequence, details, and procedures for excavation, temporary support of excavation, dewatering, foundation installation and construction, subdrainage installation, backfilling, soil management, and other related activities.
 2. Prior to start of earthwork, the Contractor's qualified, independent professional shall conduct a pre-construction condition survey.
 - a. The survey shall include the following, unless otherwise approved by the Architect:
 - 1) Utilities and site improvements to remain on and within 150 ft of the extents of the Site.
 - 2) Any other areas as may be affected by the Contractor's construction operations.
 - b. Coordinate activities, issue notices, obtain clearances and provide whatever photographic, video, and secretarial assistance is necessary to accomplish the survey.
 - c. Give notice in writing, to the owner of the property concerned, tenant of the property and any representative of local authorities required to be present at such survey. Advise in notice the dates on which surveys are to be made so that they may have representatives present during the examination. Provide copies of all notices.
 - d. Observations shall be recorded, and sufficient and detailed photographic and appropriately narrated video made, during the survey of the existing conditions for interiors and exteriors of buildings, utilities, and other structures that might be affected. Cracks, damage, or other defects shall be located and recorded to the extent that it will be possible to determine the effect, if any, of the construction operations on the defect.
 - e. The record of each property examined shall be signed by the representatives present.
 - f. Prior to start of earthwork, the Contractor's record shall be submitted to the Architect for review.
 - g. Upon completion of all excavation and backfilling work, the Contractor shall make a similar examination of any properties, structures, and conditions where complaints of damage have been received or damage claims have been filed. Give notice to all interested parties so that they may be present during the final examination. Records of the final examination shall be signed and distributed the same as the original pre-construction survey.
 3. Compaction equipment manufacturer literature and model numbers.
 4. Detailed shop drawings and calculations, to be reviewed by the Architect, of applicable earthwork procedures and sequences.
 5. Supplier quality control test results and two 50 lbs. bag/bucket samples for independent quality control testing from each borrow (off-site) source or supplier for each type of proposed material.
 6. Chemical test data and source site data on proposed borrow (imported) materials. Data shall include, at a minimum:

- a. Documentation, as judged sufficient by the Architect, confirming that all borrow materials are free of contamination. A letter, including backup data and chemical test results, from a Qualified Environmental Professional will constitute suitable documentation that the material is free of contamination.
- b. Location, address, owner's name and telephone number, and nature of the source site, including a street map with the limits of the borrow pit property and the exact location of where the borrow material will be obtained on the site clearly illustrated.
- c. Present and past usage of the source site and materials and description of abutting properties and their uses.
- d. Any previously existing report(s) associated with an assessment of the source site as relates to the presence of oil or hazardous materials.
- e. If the site characterization data indicate materials could possibly be polluted or contaminated, or the submitted chemical test data is unacceptable in the judgment of the Architect, chemical testing will be required as directed by the Architect. The chemical testing shall be completed by the Contractor in coordination with the Environmental Consultant at no additional cost to the Owner. If site characterization of off-site borrow sources indicates that soils are acceptable for use in the judgment of the Architect, then chemical testing will not be required.
7. Flowable Fill and Concrete Mix Designs: Mix designs with admixture information, and applicable laboratory test data documenting the specified properties.
8. A representative sample and literature of geotextiles. Submit manufacturer's product literature including physical properties in compliance with applicable specifications and warranty information.
9. Manufacturer literature and technical data for pipes and pipe fittings and specialties.
- B. Certification for Examination of Site and Records: Before proceeding with the work, submit certification in an acceptable form, stating that careful examination has been made of the site, adjacent structures, existing structures, records of utility lines, test boring or test pit records and reports, soil and rock samples, and the Contract Documents.

1.9 COORDINATION

- A. Prior to start of earthwork operations, the Contractor shall arrange an on-site meeting with the Owner, Architect, Owner's Representative, and other concerned entities for the purpose of establishing the Contractor's schedule of operations and reviewing observation and testing procedures and requirements. Record discussions and agreements and furnish a copy to each participant.

1.10 LINES, GRADES, AND TOLERANCES

- A. The Contractor shall be responsible for establishing lines, grades, and other survey control to complete the work. The Contractor shall be responsible for the maintenance and protection of the survey control reference points and location stakes. The Contractor shall employ a licensed Registered Land Surveyor or a Registered Civil Engineer, familiar with building construction, to establish lines and levels. The Contractor shall be responsible for the correct location of the proposed facilities, including locations and elevations and limits of excavations and fills.

- B. Construct subgrades to within ½ in. of the elevations indicated on Drawings.
- C. Maintain the moisture content of the fill material during placement within plus or minus two percent of the material's optimum moisture content per ASTM D1557.
- D. Repair and reestablish grades in settled, eroded, and rutted areas to specified tolerances.

1.11 PERMITS, CODES, AND REGULATIONS

- A. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner. Earthwork shall comply with requirements of governing agencies in the District of Columbia, where applicable.
- B. In case of conflict between regulations or between regulations and Specifications, the Contractor shall comply with the strictest applicable codes, regulations, or Specifications.
- C. Comply with the provisions of the Manual for Accident Prevention in Construction of the Associated General Contractors of America, Inc., and the requirements of the Occupational Safety and Health Administration (OSHA), United States Department of Labor.
- D. The Contractor shall procure and pay for all permits and licenses required for the complete work specified herein and shown on the Drawings.

1.12 EXISTING UTILITIES

- A. Notify 811 before site clearing or excavating. Hire private utility mark-out service for areas not marked by utility companies.
- B. Numerous subsurface utilities are present in the area of the work. The Contractor shall investigate, understand, and protect all utilities to remain as part of its work for this project.
- C. Existing utilities remaining in service, including those remaining in service until after relocation, and relocated utilities are shown on the Drawings. Before excavating near any existing utilities, notify the utility owner, coordinate protective work and comply with the utility owners' requirements. Safeguard and protect from damage or movement any existing services, utilities and utility structures uncovered or encountered which are to remain in service.
- D. Prior to beginning any excavation or fill placement, accurately locate, and mark underground utilities and appurtenances in site area. Excavate to and expose utilities at locations, and conduct field surveys as necessary to determine locations of existing utilities.
- E. Should uncharted, or incorrectly charted, piping, or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and public and private utility companies in keeping respective facilities and services in operation. Repair damaged utilities to the satisfaction of utility company as directed by the Owner.
- F. Do not interrupt existing utilities serving facilities occupied and used by Owner or others, during occupied hours, except when permitted in writing by Owner and then only after

arranging to provide acceptable temporary utility services. Provide minimum of 48-hour notice to Owner and receive written notice to proceed before interrupting any utility. Do not proceed with utility interruptions without Owner's and utility owner's written permission.

- G. In case of damage or injury caused in the performance of work the Contractor shall, at his own expense make good such damage or injury to the satisfaction of, and without cost to, the Owner and utility owner. Existing utilities damaged during the project work shall be repaired or replaced to their condition prior to commencement of earthwork operations as directed by the Owner.
- H. Inactive or abandoned utilities encountered during construction operations shall be removed, plugged, sealed, bulkheaded or capped as directed by the Owner's Representative to prevent migration of earth, water or other fluids into such utilities. The location of such utilities shall be noted on the Record Drawings and reported in writing to the Owner's Representative.
- I. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies for shut-off of services if lines are active.
- J. When in the course of the work it is necessary to connect a utility to a main in a public way, all the requirements of both the authorities governing the utility and those governing the public way shall be met. Pavement shall be temporarily and permanently replaced as directed by these authorities at no additional cost to the Owner.

PART 2 - MATERIALS

2.1 MATERIALS

- A. Earth materials for use as fills shall be as described below. All soil materials proposed for borrow shall be clean, mineral soil materials from accepted sources, free of any contamination as described in Part 1 - Submittals.
- B. Processed materials consisting of a mixture of two or more soil types (such as sand and either crushed stone, crushed concrete, or other crushed construction materials) are not acceptable for use as fill unless accepted by the Architect.
- C. Reuse on-site soils to the extent possible. On-site soils will be allowed as Common Fill and Structural Fill, if such materials meet the requirements of this Section and can be placed and compacted as specified herein, subject to acceptance by the Architect.
- D. Common Fill: Common Fill shall consist of mineral sandy soil, free of organic materials, environmental contaminants, plastic, metal, wood, loam, trash, wood, snow, ice, frozen soil, clay and other compressible or deleterious materials. Common Fill used within 4 ft of finished grade in landscaped planting areas (as shown on the Drawings) shall be free of materials deleterious to plant growth and shall be "free-draining" (see percent finer by weight below). Common Fill shall have physical properties such that it may be readily spread and compacted without excessive weaving or instability. Common Fill shall conform to the following gradation:

Sieve (ASTM D422)	Percent Finer by Weight
8-in. *	100
No. 4	20-90
No. 40	10-80
No. 200	0-30 **, ***

* when used in trenches within 2 ft of utilities, or within 2 ft of foundation walls the largest particle dimension shall be 3 inches. The size of the largest particle shall be less than 2/3 of the lift thickness. When used within 4 ft of finished grade in landscaped planting areas (as shown on the Drawings) the largest particle dimension shall be 1-3/4 in.

** when used as foundation wall backfill against drainage board, the percent finer by weight shall be less than 20.

*** when used in landscaped areas, the upper 2 ft immediately below the planting soil layer shall have a percent finer by weight of less than 8 unless otherwise approved by the Architect.

- E. Crushed Stone: Crushed Stone shall consist of inert, angular stone material derived from a stone quarry that is hard, durable, washed, and free of deleterious materials. Crushed stone shall be washed at the source site to remove fine-grained soils prior to import to the site. Gradation shall conform to AASHTO No. 57 Stone as indicated on the Drawings.
- F. Structural Fill: Structural Fill shall consist of suitable natural sand and gravel, free of organic material, environmental contaminants, debris, snow, ice, or other unsuitable materials. The fines in Structural Fill materials should have a liquid limit no greater than 40 percent and a plasticity index no greater than 10. Structural Fill should be well graded and shall confirm to the following limits:

Sieve (ASTM D422)	Percent Finer by Weight
6 in. *	100
No. 4	30 - 80
No. 40	10 - 50
No. 200	0 - 8 **

* when used in trenches within 2 ft of utilities or within 6 in. of foundation walls or slabs, the largest particle dimension shall be 3 inches. The size of the largest particle shall be less than 2/3 of the lift thickness.

** when placed in the upper 3 ft of filled areas during periods of wet and/or freezing weather, the percent finer by weight shall be less than 5 percent.

- G. Bedding Material: Sand or sandy soil free of debris, waste, frozen materials, and organic materials with 100 percent passing a 3/8 in. sieve and not more than 10 percent passing a No. 200 sieve.

- H. Sand Borrow: Sand Borrow shall consist of clean, inert, hard, durable grains of quartz or other hard, durable rock, free from loam or clay, surface coatings and deleterious materials. The maximum size for Sand Borrow shall be ¼-in. The allowable amount of material passing a No. 200 sieve shall not exceed 10 percent by weight.
- I. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand, or accepted on-site material proposed for reuse.
- J. Low Permeability Fill: shall consist of Common Fill with a minimum 20 percent passing a No. 200 sieve.
- K. Concrete: shall have a minimum 28-day compressive strength of $f'_c = 2,500$ psi, unless otherwise noted, with a maximum slump of 6 in.
- L. Flowable Fill: A mixture of Portland cement, aggregate, and water, and may include fly ash, slag cement, air-entraining agents, and other accepted admixtures, Excavatable flowable fill shall have a 28-day compressive strength of between 30 and 150 psi. Non-excavatable flowable fill shall have a minimum 28-day compressive strength of 200 psi.
- M. Geotextile Filter: Needle-punched, non-woven, synthetic, chemically resistant, non-biodegradable fabric meeting requirements of AASHTO M288 Class II Non-Woven such as Solmax (formerly TenCate) Mirafi 160N, Carthage Mills FX-50HS, ADS Geosynthetics 0601T, Propex Geosolutions Geotex 601, US Fabrics 160NW, or accepted equivalent. Fabric shall be labeled showing manufacturer name, product number and roll identification. Fabric shall be wrapped with a protective plastic from delivery until time of installation that protects against: damage by impregnation, cement, construction fluids and moisture, and ultraviolet radiation including sunlight for more than 7 total days. Fabric shall be protected against tearing, flame and chemical exposure and temperatures exceeding 160 deg F or less than -22 deg F at all times.
- N. Perforated Drainage Pipe: 6-in. diameter, perforated, solid wall, Schedule 40 PVC pipe complete with bends, wyes, tees, reducers, caps, plugs, couplers, adapters, collars and joint materials. Fittings shall be DWV type with sanitary turns. Perforations shall be two rows of 5/8-in. diameter holes every 5 inches of pipe length. Rows shall be parallel to the pipe axis and 120 degrees apart at the 2 o'clock and 10 o'clock positions. Pipe shall be delivered to the site with factory-made perforations that are clean-cut and free of frayed edges.
- O. Solid Drainage Pipe: Equal to Perforated Drainage Pipe except solid wall.
- P. Clean-outs: Z1400 by Zurn Engineered Water Solutions, 4100 by Jay R. Smith Mfg. Co., 55000 by Josam Co., or equivalents, complete with solid riser pipes, waterstop flange, covers, bends, couplers, adapters, collars, hardware, joint materials, and concrete pad (exterior locations) or approved equal. Cleanouts shall be the same size as the pipe they serve.
- Q. Choke Material: shall consist of Concrete, Flowable Fill, Crushed Stone, and/or Filter Fabric, as proposed by the Contractor and accepted by the Architect.
- R. Balance of materials shall be used as indicated on the Drawings and/or as specified elsewhere in the Contract Documents.

2.2 ACCESSORIES

- A. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 in. wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 in. deep; colored as follows:
1. Red: Electric.
 2. Yellow: Gas, oil, steam, and dangerous materials.
 3. Orange: Telephone and other communications.
 4. Blue: Water systems.
 5. Green: Sewer systems.

2.3 USE OF MATERIALS

- A. Common Fill: Use to backfill outside the ZOI of foundations including beneath pavement sections and beneath select landscaping layers in landscaped areas.
- B. Structural Fill: Use to replace unsuitable materials within the ZOI of structural elements and below utilities; as base course for site pavements and utility trench backfill unless otherwise specified; where free-draining backfill is required; and as shown on the Drawings.
- C. Sand, Low Permeability Fill, Concrete, Flowable Fill: As shown on the Drawings, as proposed by the Contractor and accepted by the Architect, or as directed by the Architect.
- D. Bedding Material: Use for utility bedding unless otherwise shown on the Drawings.
- E. Crushed Stone: Use for drainage and subgrade layers as shown on the Drawings. Crushed Stone shall be entirely surrounded (i.e., top, bottom, sides) by a separation layer (e.g., Geotextile Filter) or concrete unless otherwise accepted in writing by the Architect.
- F. Geotextile Filters: Geotextile shall be used: 1) at the locations shown on the Drawings, 2) other locations to prevent soil intrusion into drainage fill or drains, 3) assist in stabilizing subgrades prior to placement of fill materials or structures, and 4) to separate fine-grained materials from coarser-grained materials where the Architect judges that migration of fine material into coarse material could occur (e.g., between Crushed Stone and soil subgrades). Other instances may also require the use of geotextile filter, as judged necessary by the Architect.
- G. Drainage Pipe and Cleanouts: Install at the locations and elevations shown on the Drawings. Solid pipe shall be used for lateral connections between the perforated foundation drainage piping and the discharge point.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Examine the site and all Work prepared by others and report to the Architect in writing any conditions detrimental to the proper and timely completion of the Work of this Section. Do not

proceed with the Work until unsatisfactory conditions have been corrected in an acceptable manner.

3.2 GENERAL REQUIREMENTS

- A. Earthwork activities shall conform with the Contract Documents and submittals that are acceptable to the Architect. No Work shall be performed unless it is conducted under the observation of the Architect, and in accordance with the accepted schedule and sequence.
- B. Excavated materials unsuitable for reuse, and surplus excavated soil not used to fulfill requirements of the Contract, shall become the property of the Contractor, legally removed from the site and legally disposed of by the Contractor and in accordance with other Specifications, Drawings, and regulations and requirements of municipalities or agencies having jurisdiction over the disposal, disposal sites and the route between the project site and disposal sites.
- C. Control vibrations and noise associated with the work so as to prevent damage to site improvements and disturbance to occupants. The Contractor shall conduct all Work associated with this Section to maintain vibrations below the Limiting Values which may require the use of light weight compaction equipment (and corresponding smaller lift thicknesses to achieve minimum degree of compaction).
- D. Prevent erosion at the site at all times in accordance with the Specifications and/or shown on the Drawings.
- E. Explosives or blasting agents shall not be permitted on the site without prior written approval of the Owner, Architect, Owner's Representative and local authorities.
- F. If unanticipated contaminated material is suspected or encountered during an excavation, the Contractor shall contact the Owner's Representative and Architect immediately. The Owner's Representative or Architect will provide direction on how to proceed.
- G. Do not excavate or remove any material from within the site or right of way, which is not within the excavation, as indicated, without written authorization from the Owner's Representative.
- H. Some existing on-site soils may be suitable for reuse. The Contractor shall reuse on-site excavated soils as indicated herein, as accepted by the Architect. The Contractor shall conduct all on-site reuse activities, including excavating, conveying, processing, fragmenting, screening, handling, segregating, and stockpiling, at no additional cost to the Owner.
- I. Stripping, Handling, Segregating, and Stockpiling of Materials:
 - 1. Strip topsoil from within the limits of Work, unless otherwise specified, and stockpile.
 - 2. During the course of the work, various quantities of materials will be accumulated and stockpiled (on- or off-site) for future re-use on-site or for off-site disposition. All excavated soils shall be classified by the Architect prior to reuse or removal from the site. The Contractor shall handle, segregate (to prevent intermixing of different materials), protect, stockpile, reuse and/or dispose of the excavated soils, as required.
 - 3. Stockpiling shall be coordinated by the Contractor and shall comply with sedimentation and erosion control requirements contained in the Specifications and/or shown on the

Drawings. Do not stockpile materials near edges of excavations or within any restricted areas shown on the Drawings.

J. Unfavorable Weather:

1. Freezing Weather:

- a. Fill materials and/or concrete shall not be placed on snow, ice, frozen subgrades, or frozen soil. Do not place fill containing frozen materials, snow, or ice.
- b. The Contractor shall, at his own expense, keep the site clear and free of accumulations of snow and ice, or as required to carry out the Work.
- c. Fill materials and/or concrete shall not be frozen when placed or be allowed to freeze prior to, or after compaction or placement. At the end of each day's Work during freezing weather, the last lift of fill, after compaction, shall be rolled by a smooth wheeled roller to eliminate ridges of un-compacted soil. Fill materials, subgrades to receive fill or structures, and concrete shall be covered with an insulating cover or heated during freezing weather, as required to prevent frost and freezing of fill and concrete. The Contractor shall suspend backfilling operations and placement of Concrete or Flowable Fill when air temperatures are below 32°F if directed by the Owner's Representative.
- d. Soil bearing surfaces below foundations, slabs or structures shall be protected against freezing, before and after concreting. Frost protection shall be provided in a manner acceptable to the Architect as soon as possible after foundations, slabs or structures are constructed.
- e. Do not excavate to full indicated depth when freezing temperatures may be expected, unless the footing or slab is poured immediately after the excavation has been completed. Protect the excavation from frost if placing of concrete is delayed. Where footings or slabs are exposed to freezing temperatures, they shall be protected to prevent damage to the concrete by freezing or frost penetration into the soil upon which they rest. Where foundations are exposed over the winter during construction, provide earth cover above the bottom surface of concrete equivalent to the Code required frost protection depth.
- f. Subgrades that have been permitted to freeze by the Contractor will be judged to be unsuitable for placement of fill, foundations, or structures by the Architect. The Contractor at the Contractor's expense shall conduct additional investigation to determine the extent of freezing, excavate soils that have frozen, and replace with materials acceptable to the Architect.

2. Wet Weather:

- a. If fill material placement, spreading, rolling, or compaction operations are interrupted by wet weather, do not resume such operations until ascertaining that the moisture content and density of the previously placed soil are as required by these Specifications.
- b. The Contractor shall control the grading so that ground is pitched to prevent water from running into excavated areas, damaging other structures, or leaving the site.

K. Backfilling Prior to Approval of Work Installed:

1. Do not allow or cause the Work performed or installed to be covered up or enclosed by Work of this Section prior to all required observations, tests, and approvals.
2. Should any of the Work be so enclosed or covered up before it has been accepted, uncover all such Work at no additional cost to the Owner.

3. After the Work has been completely tested, observed, and accepted, make all repairs and replacements necessary to restore the Work to the condition in which it was found at the time of uncovering, all at no additional cost to the Owner.

L. Dust and Erosion Control:

1. The Contractor shall take all necessary measures and provide equipment and/or materials to minimize dust from rising and blowing across the site and also to control surface water throughout the operation so that it does not run onto paved ways without being filtered. In addition, the Contractor shall control all dust created by construction operations and movement of construction vehicles, both on-site and off-site.
2. Thoroughly moisten all surfaces as required to prevent dust being a nuisance to the public, neighbors, and performance of other Work on-site.
3. Repair any erosion and siltation control measures damaged during earthwork operations and install any additional measures necessary for proper control.

3.3 EXCAVATION

A. Dimensions:

1. Excavate to elevations and dimensions indicated on the Drawings or as otherwise required for the Work.
2. Do all necessary excavation, including, but not limited to excavation for structures, utility lines, mechanical work, mechanical and drainage structures, drains, and other below grade work. Excavate sufficient material to allow ample space for construction operations including placing and removal of forms, installation of waterproofing, damp-proofing, or utilities and observation of excavated areas.
3. Side forms will be required for all concrete work unless omission of forms is requested by the Contractor, in writing, to the Architect. Where omission of forms is requested by the Contractor, and accepted by the Architect, the Contractor shall bear the cost of any additional concrete volume required beyond the minimum profiles and dimensions of the utility trench as detailed.

B. Excavation shall include the removal of all materials encountered including earth, rock, organic soils, boulders, pavement, utilities, obstructions, foundations, slabs, incidental structures and other materials to the elevations and limits required to construct the work shown on the Drawings. Excavations for foundations shall be to naturally-deposited soil or bedrock acceptable to the Architect.

C. Excavation, subgrade preparation and backfilling shall be performed in-the-dry.

D. Where excavations are made to remove unsuitable materials beneath the planned building foundations, other structural elements, utilities, or other facilities, the horizontal limits of excavation shall be sufficient to place accepted materials beneath structures or facilities below. If such fill limits cannot be achieved, notify the Architect immediately.

E. Excavation shall not be made into the ZOI of structural elements unless otherwise accepted by the Architect. Where excavations are required to be made into the ZOI, the Contractor may be required to shore and brace to protect the materials within the ZOI from undermining, washing out, loosening, or becoming disturbed, and protect the structure from movement by

underpinning. Prior to excavating into the ZOI, the Contractor shall submit the proposed schedule, sequence, procedures, materials, and equipment to accomplish the work to the Architect for review. The Contractor is responsible to protect existing facilities to remain from damage.

- F. The Contractor shall control the grading so that ground is pitched to prevent water from running into excavated areas, damaging other structures, or leaving the site.
- G. Where soil has been softened, frozen or otherwise disturbed, it shall be removed and replaced with suitable material at no additional cost to the Owner.
- H. Exercise care to preserve materials below and beyond the lines of excavation. Where excavation is carried out, through error, below indicated grade or beyond the lines of excavation, backfill to the indicated grade and compact with acceptable materials at no additional cost to the Owner.
- I. Excavate within a radius of 1.5 times the drip line of any tree only if directed by the Architect and in coordination with the Owner's Representative.
- J. Authorized Additional Excavation: Authorized Additional Excavation is excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Where the Architect determines that the material encountered at the elevations shown is not capable of supporting the design load, or where unsuitable material is encountered, the Owner's Representative will direct the Contractor to remove and replace the unsuitable material as required herein. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
- K. Excavation: Excavate to elevations, cross sections, gradients, lines, subgrades, and dimensions indicated on the Drawings within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections. Extend excavations a sufficient depth to enable installation of base and subbase course(s), if applicable.
 - 1. General: Do not disturb bottom of excavation. Excavate by hand, or with flat-edge equipment if accepted by the Architect, at structures to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Rock: Excavate rock using mechanical methods (i.e., hoe-ramming and excavators).
 - 3. Trenches, unless indicated elsewhere: Excavate trenches to uniform widths to provide the following clearance on each side of pipe, or conduit or ductbank. Excavate trench walls vertically from trench bottom to 12 in. higher than top of pipe, conduit or ductbank.
 - a. Trench excavation shall be of sufficient width, at least 12 in. each side of pipe or conduit unless other specified, and depth at all points to allow pipes to be laid, and appurtenant work to be built in a workman-like manner and, when needed, to allow for sheeting and shoring, pumping and draining, and/or for removing and replacing any unsuitable materials.
 - b. Excavate trenches 8 in. deeper than bottom of pipe elevation to allow for bedding materials. Hand excavate for bell of pipe.
 - c. Excavations for manholes, catch basins and miscellaneous site structures shall provide 18 in. minimum clearance on all sides.

3.4 SLOPING, SHEETING, SHORING, AND BRACING

- A. The Contractor shall slope, sheet, shore and/or brace excavations in accordance OSHA 29 CFR 1926 dated October 31, 1989, and subsequent amendments and revisions, including designing, furnishing, placing, and removing (or leaving in-place if directed by the Architect). The Contractor shall be solely responsible for protection of existing or new facilities, the stability of excavations, and for maintaining site safety in accordance with OSHA and other applicable regulations. Excavation support systems shall be designed to retain and provide full support for adjacent soil, rock, structures, utilities, light fixtures, streets and other features and protect them from damage due to settlement, lateral movement, loss of ground, or any other causes related to this construction. In addition, the support system must be located to allow new construction to be completed. Excavation support systems shall be designed for all temporary and permanent loading conditions to which it will be subjected.
- B. Temporary support of excavation systems shall not extend into the ZOI of structural elements unless proposed by the Contractor and accepted in writing by the Architect.

3.5 PRE-EXCAVATION

- A. Coordinate pre-excavation activities including equipment and materials with the support of excavation wall Contractor(s). The support of excavation wall Contractor(s) shall be satisfied with the proposed work prior to commencing pre-excavation.
- B. Pre-excavate along the alignment of the temporary support of excavation walls to remove any existing below-grade structures or obstructions so that subsequent wall construction can be undertaken without impedance.
- C. Pre-excavation shall extend to naturally deposited soils or to the depth of known foundations, whichever is higher. Pre-excavation shall be a minimum of 3 ft wide (or to the top/side of existing structures).
- D. Backfill the pre-excavation with a material suitable for re-excavation with nominal effort by the support of excavation wall Contractor(s) and/or to remain as the permanent backfill. The backfill material may consist of cement bentonite or excavatable flowable fill.

3.6 SUBGRADE PREPARATION AND PROTECTION

- A. General:
 - 1. Complete the excavations to the required subgrade elevations allowing for subbase material, bedding material, plus any additional depth required to accommodate (as applicable) drainage layers, waterproofing, geotextiles, pipes, pavements, sidewalks, etc.
 - 2. All subgrades must be observed and accepted by the Architect prior subsequent work.
 - 3. The subgrade shall be made smooth, and cleaned of all loose rock and soil, and disturbed material. Remove accumulated water, silt, trash, debris, or deleterious material from temporary and final subgrades.
 - 4. Boulders exposed at the subgrade shall be removed to a depth of at least 12 in. below the required subgrade level.

5. Backfill all holes and depressions that will not otherwise be removed in the course of the Work with materials and methods acceptable to the Architect to the subgrade elevation indicated on the Drawings.
6. Where excavations are anticipated to extend below groundwater level, the subgrade shall be protected with a 6-in. thick (or thicker as required for dewatering performance) layer of compacted Crushed Stone placed over Filter Fabric.
7. Care shall be taken to avoid disturbance to natural inorganic soil or previously-placed fill subgrades in areas to receive fill or support future structures. Equipment shall not be operated on prepared soil subgrades.
8. Moisture condition (where necessary) and re-compact subgrade soils with at least four passes of suitable heavy vibratory compaction equipment until subgrade soils are firm under re-compaction, or stable under proof-rolling (less than ½ in. elastic deformation during proof-rolling) with heavy vibratory compaction equipment or a loaded 10-wheel dump truck, and otherwise suitable to the Architect. The Architect may, at its discretion, conduct field unit weight tests on the re-compacted subgrade soils prior to placement of backfill to confirm that the subgrade soils have been compacted in accordance with the requirements of this Section. The Architect may, at its discretion, waive the requirement for re-compacting subgrade soils.
9. In areas of weaving or soft or unstable soils, the soft materials shall be excavated and replaced with materials acceptable to the Architect, at no additional cost to the Owner.
10. Take measures necessary to prevent disturbance of prepared subgrades. Disturbed subgrades, as judged by the Architect, shall be removed and replaced with suitable materials and/or reshaped and recompacted as specified herein.
11. Subgrades may require choking to prevent loss of material into larger underlying void space. The need for choking of the subgrade shall be determined by the Architect at the time of preparation.
12. Excavate materials to 2 ft above the indicated subgrade level by general excavation methods. Excavate the final 2 ft with smooth-edge equipment. Backblading of surfaces to smooth disturbed soil will not be permitted.
13. Take measures necessary to prevent undermining of any structural elements, utilities, excavation support systems, and previously prepared subgrades.
14. Geotextile Filter shall be installed over soil subgrades and excavation sidewalls where shown on the Drawings, specified herein, or where the Architect judges migration of soil into subsequently placed material could occur. Geotextile Filter shall be installed in intimate contact with subgrades and sidewalls.
15. The excavation slope required to achieve foundation and slab step geometry shall be such that mechanical compaction of the subgrade may be performed.

B. Spread Footing Foundations:

1. Subgrades below foundations (footings) sized with a maximum net allowable bearing pressure of two and three-quarters kips per square foot (2.75 ksf) shall consist of undisturbed residuum soil or compacted Structural Fill.
2. Fill, soft/very loose residuum soil, and other materials which do not meet the characteristics for acceptable foundation subgrade material as determined by the Architect, if encountered at subgrade within the ZOI of foundations, shall be considered unsuitable, and over excavated and replaced with Structural Fill, Crushed Stone, or Concrete .

3. Subgrades shall be prepared as flat as practical and no steeper than 6H:1V unless otherwise approved by the Architect.
 4. The subgrade shall be made smooth, and cleaned of all loose soil or rock and disturbed material. Disturbed subgrades shall be removed and replaced with Structural Fill, Crushed Stone, or Concrete.
- C. Slabs-on-Grade:
1. Subgrades below slabs-on-grade shall consist of Structural Fill, Rock, Crushed Stone, or Concrete. Existing fill, organic deposits, debris and other unsuitable materials, if encountered at subgrade, shall be over excavated and backfilled with Structural Fill, Crushed Stone, or Concrete.
 2. Slab base course shall consist of a 6-in. thick layer of compacted AASHTO NO. 57 Crushed Stone placed over Geotextile Filter. The subgrade shall be made smooth, and cleaned of all loose rock and soil, and disturbed material prior to placement of Geotextile Filter.
- D. Structured Slabs and Pile Caps:
1. Subgrades below structured slabs and pile caps shall consist of Structural Fill, Common Fill, Crushed Stone, or existing soil. Organic deposits, debris, abandoned utilities, and other unsuitable materials, if encountered at subgrade, shall be over excavated and backfilled with Common Fill, Structural Fill, or Crushed Stone.
 2. Base course shall consist of a 6-in. thick layer of compacted AASHTO No. 57 Crushed Stone placed over Geotextile Filter. The base course shall be contiguous throughout the building, including between pile caps and slabs across changes in subgrade level. The subgrade shall be made smooth, and cleaned of all loose rock and soil, and disturbed material prior to placement of Geotextile Filter. Subgrades shall be prepared as flat as practical and no steeper than 2H:1V where required to accommodate subgrade level transitions.
- E. Utilities, unless otherwise indicated:
1. Excavate all rock, boulders, or other unyielding bearing material to at least 12 in. below bottom of proposed utility lines, or deeper if required to place bedding materials shown on the Drawings.
 2. Subgrades below utilities shall consist of undisturbed, naturally deposited inorganic soils or rock, or re-compacted existing fill soils that are free of organic matter, stable under proof-compaction, and otherwise suitable to the Architect. Unsuitable soils, materials, or soft, disturbed, and unstable soils present at the subgrade level shall be over-excavated up to 18 in. below subgrade level and backfilled with Structural Fill, or other materials accepted by the Architect.
 3. Excavations for manholes, catch basins and utility structures shall provide 18 in. minimum clearance on all sides.
 4. Trench excavation shall be of sufficient width, at least 12 in. each side of pipe or conduit unless other specified, and depth at all points to allow pipes to be laid, and appurtenant work to be built in a workman-like manner and, when needed, to allow for sheeting and shoring, pumping and draining, and/or for removing and replacing any unsuitable materials.

3.7 INSTALLATION OF GEOTEXTILES

- A. Install Geotextile Filters against the earth material indicated on the Drawings. Earth shall be unfrozen, smooth and free of debris, loose soil or rock, and irregularities including voids and projections.
- B. Geotextile Filters shall be free of tension, wrinkles, folds, and in intimate contact with earth when placed. Unroll geotextiles during placement directly on the earth to receive the geotextile and in the direction of future fill placement. Unroll, cut, and place sufficient geotextile to allow for overlap widths and, where installed in trenches, the trench perimeter. Upstream/upslope geotextile shall overlap downstream/downslope geotextile. Anchor geotextiles using hand-placed Crushed Stone to prevent displacement until backfilling.
- C. Overlap width shall be a minimum of 3 ft from roll to roll. Overlap width at the top of geotextile-lined trenches shall be equal to the width of the trench or 12 in., whichever is greater.
- D. If sufficient backfill thickness for protection of the installed Geotextile Filter is not placed immediately after installation, place sacrificial layers Geotextile Filter or other protective material to prevent damage to installed Geotextile Filters. Sacrificial or protective material shall be removed by hand prior to final backfilling.
- E. Replace geotextiles damaged prior to backfilling. Traffic directly on geotextiles shall be limited to foot traffic.
- F. Backfill shall be placed immediately over the geotextile. Backfill shall be a minimum 12 in. thick prior to equipment traffic over the geotextile. Backfill in trenches shall be a minimum of 3 in. thick prior to foot traffic. Backfill shall not be dropped onto geotextiles from a height greater than 3 ft.

3.8 INSTALLATION OF FOUNDATION DRAINAGE

- A. Install pipe systems to the horizontal and vertical lines and grades shown on the Drawings.
- B. Drainage pipe systems and cleanouts shall be constructed to enable conventional cleaning equipment (e.g., jetting) to reach all points in the system from cleanout locations.
- C. Components of the drainage systems that are damaged by the Contractor or contaminated with soil or other deleterious materials shall be replaced by the Contractor at no additional cost to the Owner and with no schedule impact to the Project.
- D. Penetrations through concrete shall be accomplished by providing sleeve pipes cast into and through these elements or by drilling holes through the elements if approved by the Architect. The Contractor shall not jackhammer, chip or chisel holes to construct the sleeves. After centering the pipe in the hole, the annular space between sleeve pipes and product pipes shall be sealed with a non-degradable, elastic sealant material proposed by the Contractor and accepted by the Architect. Sleeves shall provide a 1-in. minimum annular space between the pipe and the sleeve all around. Rigid materials shall not be placed between the pipe and sleeve.

- E. Place Crushed Stone in 6-in. maximum thick lifts and compact each lift with at least four passes of mechanical vibratory compaction equipment except within 12-in. around and above. Hand-tamp around and above pipes.
- F. Interior of all piping shall be completely free of deleterious materials and other potential clogging contaminants before and after installation and shall be kept clean throughout construction. Pipe sections and fittings shall be cleaned and joined using adhesives, clamps, or other means in accordance with manufacturer recommendations.
- G. Install cleanouts, terminations, outlets, connections, and other fixtures at the locations and configurations shown on the Drawings. Cleanouts must be accessible during and after construction.
- H. Provide sleeves through concrete walls at the locations shown on the Drawings or as required. Penetrations through structural elements, and waterproofing, dampproofing, vapor barrier, and moisture barrier materials shall be sealed in accordance with manufacturer requirements and Related Sections.
- I. Crushed Stone installed at the pipe haunch and shoulder during initial backfill shall be continuous with the Crushed Stone layer below slabs.
- J. Provide continuous 12-in. minimum overlap between foundation wall drainage boards and Crushed Stone/Filter Fabric layers.

3.9 PLACEMENT AND COMPACTION OF FILL MATERIALS

- A. Place and compact backfill in excavations promptly and as soon as possible, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
 - 2. As-built surveying for Record Documents.
 - 3. Testing and inspecting underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing unsuitable materials including trash and debris.
 - 6. Removing temporary shoring and bracing, as applicable.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls, as applicable.
 - 8. Installing geotextile filters to prevent migration of fine material into voids spaces of material in contact with backfill.
- B. Reuse of Excavated Soils and Materials
 - 1. The Contractor shall perform the work to maximize the reuse of excavated soils, subject to the requirements of this Section. Unless superseded by environmental or geotechnical reuse requirements, excavated soils should be reused in the same location and at the same depth that they were excavated.
 - 2. The Contractor shall coordinate, sequence, and schedule work as required to enable reuse of specified soils on-site.

3. Soils designated for on-site reuse shall be processed (i.e., screened to remove oversize cobbles or boulders and debris), moisture conditioned, and protected from the weather, as necessary, to maximize reuse. Soil that becomes unusable due to the Contractor's activities or lack thereof shall be disposed off-site in accordance with this Section at the sole cost of the Contractor. Such activities are considered those that the Contractor undertakes (or does not undertake) which result in excavated soils not being able to be reused at the time the soils are required for reuse (e.g., trafficking over prepared surfaces, failure to cover stockpiles, comingling, etc.).
4. Demolition materials and debris from foundations and utilities shall be separated from excavated soils.

C. Fill Placement

1. Place and compact fill to the limits, of the types and in the manner as specified herein and shown on the Drawings. Unless otherwise specified or directed, material used for filling and backfilling shall meet the requirements specified herein. If material removed from the excavations does not meet requirements specified herein, submission of proposed material(s) is required.
2. Slope and compact soil surfaces at the end of each day to provide for free surface drainage.
3. Placement of fill shall not begin prior to observation and acceptance of subgrade conditions by the Owner's Representative. The Contractor shall not place or compact fill material in the absence of the Owner's Representative.
4. Protect foundations, footings, waterproofing, utilities and other facilities during backfilling. Repair damage at no additional cost to the Owner.
5. Backfill shall not be placed against walls creating an unbalanced condition until they are braced or have cured sufficiently to develop strength necessary to withstand, without damage, pressure from backfilling and compacting operations. At walls not designed to resist lateral earth pressures, maintain the difference in elevation of the top of the backfill on either side of the wall within 2 ft.
6. If weaving or instability is observed during compaction, as judged by the Owner's Representative, compaction efforts shall be discontinued until the Contractor stabilizes the subgrade. If required, the Contractor shall excavate and replace the unstable fill material with acceptable compacted material, at no additional cost to the Owner.
7. Compaction shall be performed using accepted vibratory compaction equipment. Compaction by puddling or jetting is prohibited.
8. Control groundwater and surface run-off to minimize disturbance of material being placed. Dewater all subgrades prior to filling. Place all fill in-the-dry on stable, undisturbed subgrades.
9. Trench Backfill:
 - a. Utility bedding material shall be deposited in the trench, uniformly on both sides of the pipe, for the entire width of the trench to the springline of the pipe. The backfill material shall be placed by hand shovels, in layers not more than 6 in. thick in loose depth, and each layer shall be thoroughly and evenly compacted by tamping on each side of the pipe to provide uniform support around the pipe, free from voids.
 - b. Trench backfill material above the utility bedding material may consist of the excavated soils, provided the excavated soils meet the fill requirements for the

intended area (e.g., building slabs, parking areas, etc.), and can be readily spread and compacted.

- c. Backfill shall be made to grades required to establish the proper pavement section, landscaping section, etc.
- d. Any trenches or excavations improperly backfilled or where settlement occurs shall be reopened, to the depth required for proper compaction, then refilled and compacted with the surface restored to the required grade and condition, at no additional expense to the Owner.
- e. During filling and backfilling operations, pipelines will be checked by the Contractor to determine whether any displacement of the pipe has occurred. If the inspection of the pipelines shows poor alignment, displaced pipe or any other defects, the condition shall be remedied in a manner satisfactory to the Architect at no additional cost to the Owner.

D. Compaction Equipment

1. Light-weight Compaction Equipment: Compaction equipment used within 25 ft (in any direction, from any point) of existing foundations shall consist of vibratory plate compactors weighing less than 200 pounds applying a dynamic centrifugal force of less than 3,500 pounds or other similar accepted, light-weight equipment that is sufficient to provide a firm, stable subgrade and achieve the required compaction. The Contractor shall increase the 25 ft distance as required to meet the maximum vibration criteria.
2. Regular-weight Compaction Equipment: Compaction equipment used in areas beyond the area noted above may consist of a walk-behind vibratory drum roller, or reversible plate compactor, or other equivalent equipment having less than 7,000 pounds centrifugal force that is sufficient to provide a firm, stable subgrade and achieve the required compaction.
3. The Contractor shall use acceptable compaction equipment to obtain the specified compaction. In some cases, additional passes or thinner loose lifts may be required. The gradation of some materials is such that field unit weight testing methods may not provide representative compaction results. In these cases, the Owner's Representative will use judgment in evaluating if the Contractor achieved the intent of the specification.
4. When acceptable compaction equipment cannot be used in tight access areas (e.g., around and below existing or new utilities), the Contractor shall place flowable fill or concrete, subject to the acceptance of the Architect, at no additional cost to the Owner.

E. Compaction Requirements

1. Compaction shall not cause vibrations that exceed the Limiting Values specified in the Related Sections.
2. The Contractor will conduct in-situ density testing following compaction of fill as a means of control. The Contractor in coordination with the Owner's Representative will determine the acceptable in-place density test method and frequency of testing.
3. The degree of compaction is expressed as the in-place dry unit weight as a percentage of the maximum dry density at optimum moisture content as determined by ASTM Test D1557. Fill and backfill shall be compacted to at least the following minimum compaction requirements:

<u>Area</u>	<u>Minimum Compaction Percent</u>
Within ZOI of structural elements and within buildings	95%
Within 3 ft below exterior slabs, sidewalks, pavements	95%

Deeper than 3 ft below exterior slabs, sidewalks, pavements	92%
Landscape areas	85% to 92%*

*as directed by the Architect

F. Moisture Control

1. The fill should generally be within 2 percent of its optimum moisture content to facilitate compaction.
2. Fill too wet for proper compaction shall be harrowed or otherwise treated to achieve compaction to the required density. Fill that cannot be dried shall be removed and replaced with drier material.
3. Fill too dry for proper compaction shall be watered uniformly over the surface of the top loose layer. Sufficient water shall be added to allow compaction to the required density.
4. Soils excavated from on-site may be too wet or too dry and may require moisture conditioning prior to reuse on-site in order to provide a firm, stable subgrade and achieve the specified compaction requirements. It shall be assumed for bidding purposes that soils within the existing building are too dry and will require wetting to achieve the requirements herein.

G. Lift Thickness

1. Place fill in uniform horizontal layers.
2. Place fill in layers not to exceed 6 in. in loose lift thickness prior to compaction when using Light-weight Compaction Equipment, and 12 in. when using Regular-weight Compaction Equipment.
3. Compact material with a minimum of 4 complete coverages per lift.

H. Protection of Fill

1. Newly graded areas shall be protected from the actions of traffic and erosion. Damage to any lift caused by equipment shall be fully repaired by the Contractor prior to placement of overlying materials at no additional cost to the Owner.
2. The Contractor shall not disturb subgrade and underlying natural soils or compacted fill during filling operations. Methods of filling shall be revised as necessary to avoid disturbance of subgrade and underlying soils, including restricting the use of certain types of construction equipment and their movement over sensitive or unstable materials, dewatering, and other acceptable control measures. Disturbance shall be construed to include deterioration of fill, before or after placement and satisfactory compaction, due to the Contractor's operations, such as moving equipment, traffic, etc. Disturbed areas shall be fully repaired (e.g., excavate, replace, scarify surface, re-shape, compact, etc.) by the Contractor prior to placement of overlying materials at no additional cost to the Owner.
3. In the event of and prior to unfavorable weather, the Contractor shall suspend fill operations (placing, spreading and compaction) immediately and shall take steps to keep the site as well drained and insulated as possible. Fill operations shall not be resumed until the frost condition and moisture content of the fill meets the requirements of the Specifications.
4. Keep free of trash and debris.

I. Rough Grading

1. Rough grading shall include cutting and filling, shaping, trimming, rolling, finishing, and maintaining of the surface of the subgrade, including temporary subgrades, in accordance with the various depths as shown on the Drawings and as specified herein. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.
 2. Allow no stones over three inches (3 in.) in diameter within the upper 6 in. of subgrade material, unless more stringent criteria apply.
 3. Complete grading operations after site improvements have been installed and materials, rubbish and debris from such operations have been removed from the site. Leave subgrades clean and at required elevations. Provide sufficient grade staking to witness correct lines and grades.
- J. Final Surface
1. Upon completion of the work, ground surface shall be left and maintained in a firm, stable, unyielding, uniform condition, free of ruts and surface irregularities, in accordance with the grading requirements shown on the Drawings. All final surface grades and subgrades shall be prepared within ½ in. of the grades shown on the Drawings. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.
 2. Uniformly smooth-grade all areas to be graded, as indicated and as directed, including excavated sections and all areas disturbed as a result of the Contractor's operations.
 3. Where settling is measurable or observable at excavated areas during general project warranty period, remove surface (pavement, lawn or other finish), add material, compact, and replace surface treatment. Restore appearance, quality, and condition of surface and finish to match adjacent work and eliminate evidence of restoration to greatest extent possible.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

- A. Earthwork shall not be measured and shall include all excavation, demolition, handling, processing, conditioning, borrow, filling, backfilling, compacting, grading, off-site disposal, dewatering, and other work of this Section.
- B. No separate measurement for payment will be made for acquisition of permits, materials, backfill, material processing, equipment, material disposal, construction dewatering, rock excavation, stockpiling, material rehandling, surveying, or other associated items or work considered incidental to the conduct of earthwork.

4.2 PAYMENT

- A. Payment for Earthwork will be made at the contract lump sum price, which shall include full compensation for furnishing all material, labor, equipment, tools, and incidentals necessary for completing the Earthwork specified in this Section.

END OF SECTION 312300

SECTION 316333 – MICROPILES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. Provide all facilities, labor, materials, equipment, transportation, supervision, and related work necessary to complete the Work specified in this Section, and as shown on the Drawings.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section. All Work under this Section of the Specifications shall be performed in accordance with Division 01 (General Requirements).
- C. Coordinate work with that of all other trades affecting or affected by the Work of this Section. Cooperate with such trades to ensure the steady progress of all work under the Contract.
- D. All work shall be performed in accordance with applicable codes, permits and regulations, and the requirements of all local, state, and federal agencies having jurisdiction over the work.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.

1.3 DESCRIPTION OF WORK

- A. Work to be done under this Section includes, but is not limited to, providing all labor, materials, equipment, and incidentals as necessary to conduct and complete the Work specified herein and shown on the Drawings.
 - 1. Designing micropiles (“piles” in this Section) for the allowable design capacities in compression, tension and lateral loading and pile head movement shown on the Drawings.
 - 2. Installing micropiles shown on the Drawings in accordance with the requirements herein.
 - 3. Performing pile load tests to confirm assumptions made in the design.
 - 4. Providing survey control, layout and as-built plans.

1.4 RELATED SECTIONS

- A. Related Sections:
 - 1. 031000 Concrete Forming and Accessories
 - 2. 033000 Cast-in-Place Concrete
 - 3. 312300 Earthwork

1.5 REFERENCES

- A. FHWA, 2005: “Micropile Design and Construction (Reference Manual for NHI Course 132078),” Prepared for the Federal Highway Administration by P. Sabatini, et. al., Publication No. FHWA-NHI-05-039, December 2005.

1.6 DEFINITIONS

- A. Refer to Section 011000 for definition of Owner, Architect, Construction Manager, Owner's Representative, and Contractor. In this Section the term Contractor may refer to the Construction Manager as Constructor or Construction Contractor.
- B. Bidder: Entity bidding to complete the Work of this Section. After award of the contract, the Bidder becomes the Contractor for the purposes of this Section.
- C. Site: Refer to the limits of construction shown on the Drawings.
- D. Site Improvements: shall include, but not be limited to, buildings, structures, foundations, underground and above-ground utilities, pavements, landscaping, plants, slabs, sidewalks, curbs, and all other site features that are outside the limits of the site, and/or those elements within the limits of the site that are to remain.
- E. Exploration: shall include, but not be limited to, test borings and test pits and results of field and lab testing.
- F. Building Code or Code: Refer to the standards and regulations indicated on the Drawings.
- G. Bedrock: residual metasedimentary disintegrated rock also known as residuum.

1.7 PROJECT CONDITIONS

- A. Prior to submitting a bid, the Bidder shall review and understand the information contained in the following documents. These documents are made available to the Bidder for informational purposes only. The subsurface conditions information presented in these documents, as applicable, are for informational purposes only and shall not be interpreted as a warranty of subsurface conditions whether interpreted from written text, exploration results, laboratory results, or other data or interpretations of data.
 - 1. "Report on Geotechnical Engineering Study, Construct Arabian Leopard Habitat, National Zoological Park, 3100 Connecticut Avenue NW, Washington, DC" prepared by Haley & Aldrich, Inc., dated March 2026.
- B. Prior to submitting a bid, the Bidder shall examine the records of subsurface features including but not limited to utilities and foundations, records of explorations, and the exploration samples to determine conditions under which the Work will be performed. The exploration samples are available for review at Haley & Aldrich, Inc., Vienna, Virginia.
- C. The exploration information represents subsurface conditions at the exploration locations at the time conducted. Data on indicated subsurface conditions are not intended as representations or warranties of accuracy or continuity between explorations. It is expressly understood that the Owner and Architect will not be responsible for interpretations or conclusions drawn there from by the Bidder.
- D. The Contractor may perform additional explorations and laboratory testing or field screening for their own information at no cost to the Owner following approval in writing from the Owner. The Bidder shall include the cost of any additional studies it deems necessary to properly perform the Work specified in this Section, in the Related Sections, and as shown on the Drawings.

- E. If, during the course of construction operations, conditions differing substantially from those indicated in the documents referenced in this Section are encountered, promptly notify the Owner's Representative and Architect in writing, and do not disturb such conditions until directed. The Owner, Owner's Representative, and Architect will investigate such conditions, and, if it is determined that the conditions differ substantially from those that reasonably would have been anticipated from examination of the subsurface information and site, and that such conditions will necessitate a change in the Work, the Architect will recommend any required changes and adjustments in writing. Oral or written communications with field personnel shall not constitute acknowledgment of a differing subsurface condition.

1.8 QUALITY CONTROL AND ASSURANCE

- A. The Owner's Representative may observe the Contractor's micropile installation and testing activities. The Contractor shall provide sufficient notice to the Owner's Representative to allow the Owner's Representative to be present to observe each of the activities of this Section. The Contractor shall cooperate with the Owner's Representative in all respects to facilitate any testing or observations.
- B. The Architect will observe the Contractor's micropile construction activities. The Contractor shall provide sufficient notice to and cooperate with the Architect in all respects to facilitate their observations.
- C. The presence of the Construction Manager Owner's Representative or Architect shall not relieve the Contractor of its responsibility to perform the Work in accordance with the Contract Documents, nor shall it be construed to relieve the Contractor from full responsibility for the means and methods of construction, quality control, protection of site improvements against damage, and for safety on the construction site.
- D. The Contractor shall adhere to the applicable requirements of the Specifications, Occupational Health and Safety Administration (OSHA) Standards and to all other applicable ordinances, codes, statutory rules, and regulations of federal, state, and local authorities having jurisdiction over the Work of this Section.
- E. Work not in conformance with the specified requirements shall be improved, or removed and replaced, at no additional cost to the Owner. Costs related to evaluation and testing of nonconforming Work or materials shall be paid for by the Contractor at no additional cost to the Owner.
- F. Rejected piles include piles that do not conform to project requirements (e.g., installed out of tolerance, low-strength grout) and those that are damaged.
- G. The Contractor shall be responsible for establishing lines, grades, and other survey control to complete the work. The Contractor shall be responsible for the maintenance and protection of the survey control reference points and location stakes. The Contractor shall employ a licensed Registered Land Surveyor or a Registered Civil Engineer, familiar with building construction, to establish lines and levels. The Contractor shall be responsible for the correct location of the proposed facilities, including locations and elevations and limits of excavations and fills.
- H. Welding shall be performed by operators who have been previously qualified by tests as prescribed in the AWS. Evidence that welders meet qualification requirements shall be

submitted to the Architect before welding is begun. Welders shall demonstrate previous successful experience in permanent welding to the type of micropile casing used.

- I. The Contractor shall be responsible for the design of micropiles. The Contractor shall employ or retain a licensed Registered Civil Engineer, familiar with micropiles, to prepare and stamp drawings and calculations.
- J. Shop drawing and pile load test submittals shall be signed and sealed by a Professional Engineer registered in the District of Columbia
- K. Field Monitoring and Testing:
 - 1. Full-time field monitoring of the micropile installation operations, including cement grout placement, will be provided by the Contractor. No piles shall be installed or grouted except in the presence of the Contractor.
 - 2. Field monitoring of installation shall include observation and accurate measurement and recording of the following for each micropile.
 - a. Micropile designation, Contractor names, project identification and design information.
 - b. Date, times and durations of installation and grouting activities.
 - c. Inclination, plumbness, casing diameter and thickness, reinforcement size and length, casing plunge length and installed length, bond (uncased) length, total pile length as measured by weighted tape, and cleanliness of bottom of pile. All lengths shall be to the nearest inch and referenced to the design pile cut off elevation.
 - d. Drilling method, drill bit size and type, and any unusual conditions observed such as escape of drill fluids to the surface outside the casing.
 - e. Depth to top of bedrock from design pile cutoff elevation and any unusual soil conditions encountered such as boulders or difficult drilling.
 - f. Grout mix, density, quantities, placement method and any unusual conditions observed such as loss of grout through the bond length or to the ground surface.
 - g. Deviations from this Section.
 - 3. Cement grout test cylinders shall be taken and tested by the Contractor in accordance with ASTM C109. The Contractor shall obtain a minimum of two three-day and two twenty-eight day compressive strength tests per production grout batch. Three sets of three tests each for three-day, seven-day, and twenty-eight day compressive strength tests for each sacrificial pile shall be obtained. The Contractor is responsible for storing grout cylinders in an approved storage box, provided by the Contractor, for 24 hours after molding and held at a temperature between 60 to 80 degrees F.
 - 4. Grout consistency as measured by grout density shall be determined by the Contractor in accordance with ASTM C188 or API RP-13B-1 with a Baroid Mud Balance at a frequency of at least one test per pile, conducted just prior to start of pile grouting. The measured grout density shall be within 10% of the density indicated on the accepted submittal.
 - 5. Certification of the quality of the pile materials to be used in the Work shall be furnished, in a form acceptable to the Contractor, at the time of delivery of materials to the site. Pile materials shall also be subject to on-site observation for conformance with specifications.
 - 6. Approvals and acceptance given by the Architect shall not relieve the Contractor of responsibility for performing the Work in accordance with the Contract Documents and the Code.
- L. The Contractor shall be responsible for damage to any structure due to its work, and for corrective action or repairs needed to restore the structure to its original condition at no cost to the Owner and no schedule impact to the Project. Where structures are adversely affected by the

Contractor's operations, or lack thereof, the Contractor shall conduct restoration at no cost to the Owner and no schedule impact to the Project.

M. Pile Load Testing:

1. Performance static pile load testing shall be completed on sacrificial micropiles prior to installation of production piles to confirm the design assumptions including the allowable bond stress in rock, allowable compression and tension capacities, allowable lateral capacity, intended maximum pile head movements, and installation methods and equipment.
2. Pile load testing shall be performed on piles constructed using the same materials and procedures as piles in this Section and as shown on the Drawings. Locations of test piles shall be proposed by the Contractor for review by the Engineer. Testing shall be conducted under the observation of the Owner's Representative and Architect.
3. The pile load testing schedule is:
 - a. One tension load test in accordance with ASTM D3689-22 (latest reapproval). Testing apparatus shall be capable of a maximum test load of 250% of the design compression or tension load, whichever is greater. Results of tension load test are intended to satisfy the testing for compression capacity.
 - b. One lateral load test in accordance with ASTM D3966-22 (latest reapproval). Testing apparatus shall be capable of a maximum test load of 250% of the design lateral load.
4. Load testing schedules and pile acceptance criteria shall be in conformance with FHWA, 2005, Chapter 7.4.
5. Testing reaction frame shall be sufficiently rigid and of adequate dimensions such that excessive deformation of the testing equipment does not occur to safely support 125% percent of the maximum test load. Align the jack, bearing plates and stressing anchorage to prevent unloading and repositioning of the equipment during the test.
6. Monitor the creep test load hold during performance tests with the pressure gauge. Maintain a constant load hold during the creep test load hold.
7. Piles may not be loaded until the cement grout has achieved the design compressive strength.

N. Lines and Grades:

1. The Contractor shall maintain a maximum lateral deviation from the design location at cut-off elevation as submitted by the Contractor and reviewed by the Architect. A maximum deviation from design cut-off elevation as submitted by the Contractor and reviewed by the Architect will be permitted.
2. The Contractor shall be responsible for the correct location of piles.
3. The Contractor shall establish, maintain, and record all locations and elevations of micropiles, including the elevation of the top of the pile before and after cut-off, the bottom of the pile and casing, and the location relative to permanent site features.

O. Qualifications

1. The Contractor (including the personnel assigned to this project) shall have a minimum of 5-years' experience in the work specified in this Contract and shall have successfully completed a minimum of 5 similar projects.
2. The Contractor shall have available and be thoroughly familiar with the specialized type of equipment needed to perform micropile work in restricted sites with adjacent sensitive receptors.

3. The Contractor's Professional Engineer shall have a minimum of 5-years' experience involving the design of micropiles similar to those required for this project and shall have successfully completed a minimum of 3 similar projects.
4. The Contractor's field monitoring and testing personnel shall have a minimum of 3-years' experience involving drilled deep foundations, grout compressive strength and density tests, and pile material inspections and shall have successfully completed a minimum of 3 similar projects.

1.9 SUBMITTALS

A. General: Qualifications of the Contractor.

B. Shop Drawings:

1. Shop Drawings showing pile layout with unique pile identifications, and locations of sacrificial piles for pile load testing.
2. Shop Drawings showing dimensioned typical pile cross-section(s) with ground surface at time of installation, subsurface strata, and pile cap connection.
3. Details and manufacturer literature showing pile diameters and materials, length in bearing stratum, and dimensions and details of all pile components, pile-to-cap connections, and joints.
4. Load testing and acceptance criteria, field monitoring and testing schedules, and tolerances.
5. Calculations package with design criteria, assumptions, references, calculated geotechnical and structural capacities in all single and combined loading cases, pile head axial and lateral movements, group effects, casing joint tension and bending capacities, pile head reactions, and material strengths.

C. Installation:

1. Details of equipment and procedures for pile installation including but not limited to laydown and staging areas, equipment travel routes, work requiring coordination with other trades, pile construction sequences, means of handling drilling flush and grout spoils, number of drill rigs, drill rig manufacturer and model, means and methods for drilling through material types anticipated, and means and methods and sequence for installation of all pile components to achieve the project requirements.
2. Welding Procedure Specification conforming to AWS D1.1.
3. Cement grout mix design, manufacturer information for all materials to be incorporated in the mix, representative test results for the design mix, and procedures and equipment for batching and placing grout.
4. Casing and reinforcement segment lengths.
5. Casing threaded joint details and, if available, manufacturer's test results of casing joints in tension and bending.
6. Submit (for record) certified mill test reports, properly marked, for all steel components, as the materials are delivered. The ultimate strength, yield strength, elongation, and materials composition shall be included. For primary steel casing, a minimum of two representative coupon tests or mill certifications on each load delivered to the project. For secondary steel casing, submit verification of steel quality through tensile and chemical testing of steel samples and a minimum of two representative coupon tests.
7. The following records shall be prepared and completed within 24 hours after each pile installation is completed. Piles shall be grouped by pile cap/column identification. The records shall include the following minimum information:

- a. Pile drilling duration and observations (e.g., flush return, resistance) and water levels including unusual installation behavior (e.g., interaction, water loss, misalignment, drill chatter prior to reaching top of rock)
 - b. Information shown on the pile schedules, indicating as-built information which differ
 - c. Final tip elevation, bond length and diameter, and cut-off elevation
 - d. Length of casing segments and depth to uppermost joint below cut-off
 - e. Rated load capacities
 - f. Deviations from this Section or Submittals
 - g. Grout quantities pumped
- D. Pile Load Testing:
1. Narrative of procedures for pile load testing and sample data recording forms.
 2. Load testing schedule, test sequences, and plan locations.
 3. Type and calibration reports for each test jack, pressure gauge, and master pressure gauge to be used shall be submitted. The calibration tests shall have been performed within one year of the date submitted.
 4. Type and accuracy of the load measuring and application devices, pile movement and reaction frame measuring devices, and calibration reports.
 5. Type and capacity of reaction load system including details, sections, and calculations.
 6. Criteria for termination and acceptance of load test results.
 7. Written report with test pile installation details, soil and rock conditions, load test details, test methods and acceptance criteria, load measuring and application device information and calibrations, materials, load test data and procedure, data, personnel attending, data graphs, figures, results, analysis and conclusions. Data shall also be provided in raw electronic file format.
- E. As-Built Data: Actual pile location data shall be submitted within two working days after a pile is installed. The Contractor shall provide the Architect with written tabulation with pile designations, elevation of the top of each pile after cut-off (measured to the nearest 1/4 in.), and deviation from design plan location (measured to the nearest 1/4 in.).

1.10 MINIMUM PILE DESIGN CRITERIA

- A. Design and installation details of the piles shall be in accordance with approved submittals and the following:
1. Design the piles for structural loading at the pile head with appropriate factors of safety and to limit movement of the piles at the pile head to meet structural performance criteria.
 2. Design compression, tension and lateral loads shown on the Drawings and lateral deflection of 1/2 in. maximum at all design load cases.
 3. Spacing between micropiles shall be at least the center-to-center spacing shown on the Drawings.
 4. Piles shall derive their geotechnical resistance to compression and tension loads using friction between grout and bedrock and to lateral loads using passive soil pressure in the upper 15 ft of the micropile below the pile cap.
 5. Allowable stresses in grout and steel shall conform to the Code.
 6. Permanent casing shall extend to 15 ft min. below the pile cap and 2 ft min. below top of bedrock.
 7. Bond length in bedrock shall be determined using a maximum allowable side resistance of 2.5 ksf (17.5 psi) unless applicable load test data substantiate a greater value is submitted and accepted by the Architect.

8. Reinforcement shall be full length, Grade 75 min., and surrounded with 1.5 in. min. of grout cover.
9. Centralizers shall be used to center reinforcement at maximum 10 ft spacing.

1.11 MINIMUM PILE INSTALLATION TOLERANCES

- A. Unless otherwise indicated on the Drawings or in accepted shop drawings, the following shall be the maximum installation tolerances for micropiles:
 1. Centerline of micropile shall not be more than 3-in. from indicated plan location.
 2. Pile shall be plumb within 2 percent of total-length design plan alignment.
 - a. Battered piles inclined up to 1:6 (10 degrees) shall be within 4 percent of design plan alignment.
 - b. Battered piles inclined greater than 1:6 (10 degrees) shall be within 7 percent of design plan alignment.
 3. Top elevation of pile shall be plus 1 inch or minus 2 inch maximum from vertical design elevation indicated.
 4. Centerline of reinforcing steel shall not be more than 3/4-in. from indicated center of pile.

1.12 CONDUCT OF THE WORK

- A. The Contractor shall provide provisions to control exhaust from equipment, the flow of water/cuttings and disposal of same, and shall keep the premises clean and free of water and debris from the drilling/pile installation work, such that other work activities are not interrupted.
- B. Pile Interaction and Sequencing:
 1. Pile installation sequence shall be determined prior to the start of Work.
 2. Sequence of pile installation shall be such that adjacent piles, or piles located less than 4 ft center-to-center from a previously grouted pile, are not installed within 24 hours after grouting of the adjacent/ previously installed pile.
 3. If interaction between new/fresh drilled piles is observed during drilling, the drilling operations shall cease immediately, until the "fresh" drilled pile has cured (a minimum of 24 hours). Drilling may commence at other drilled pile locations.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Water: Water for mixing grout shall be potable, clean, and free from substances which may be in any way deleterious to grout or steel.
- B. Cement Grout: Cement Grout for piles shall conform to the requirements of the Code and ASTM Specification C94 for Ready Mixed Concrete, Third Edition. Cement shall be Portland and conform to ASTM C150, Types I, II, or III. The minimum 3-day compressive strength shall be 50% of the minimum 28-day compressive strength. The compressive strength shall be determined in accordance with ASTM C109. Admixtures, if submitted by the Contractor and accepted by the Architect, shall be mixed in accordance with manufacturer's recommendations.
- C. Casing: Manufactured to conform to American Petroleum Institute (API) 5CT, Grade N80 or better, or 5L, Grade X52. The permanent steel casing shall also meet the tensile requirements of ASTM A252, Grade 3, except the minimum yield strength shall be 80 ksi and minimum

elongation shall be 15%. Lengths sufficient to achieve the joint position requirements shall be supplied. For casing requiring structural welding:

1. The carbon equivalency as defined in AWS D1.1, Section XI5.1, shall not exceed 0.45.
2. The sulfur content shall not exceed 0.05%.

- D. Reinforcing Bar: Reinforcing steel shall be threaded, deformed bars in accordance with ASTM A615, Grade 420 or 520, or ASTM A722, Grade 1035. Bar couplers shall develop the ultimate tensile stress of the bar, without any evidence of failure. For compressive loading, the coupler shall be compatible with efficient load transfer and overall reinforcement performance requirements. Thread shall be continuous spiral deformed ribbing supplied by the manufacturer.
- E. Centralizers: Centralizers shall be fabricated from Schedule 40 PVC plastic tube or pipe, steel, or material that is non-detrimental to the reinforcing steel. Wood shall not be used.
- F. Pile-to-Cap Connection Components: Unless otherwise shown on the Drawings, structural steel plates and shapes for pile top attachments shall conform to ASTM A36 or ASTM A 572, Grade 350.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

- A. Piles shall be installed at the locations and to the line and grades specified in the Drawings and Contractor's submittal.
- B. Pile installation activities shall conform with the Contract Documents and submittals that are acceptable to the Architect. No Work shall be performed unless it is conducted under the observation of the Contractor, and in accordance with the submitted schedule and sequence.

3.2 METHOD OF INSTALLATION

- A. The method of pile installation shall be determined by the Contractor, subject to review by the Architect. Pile installation shall be made by non-displacement, low vibration methods such as rotary drilling. Wet rotary drilling methods shall employ sufficient fluid pressure to provide complete removal of the drill cuttings and materials from the cased hole. Air drilling may be used provided the materials and tooling is specially designed and operated to direct primary air flush up through the inside of the casing and remove material in front of the drill with a minor amount of air flush across the drill face. These specially designed tool systems include, but is not limited to, the Spiral Flush system manufactured by Mincon.
- B. Internal drilling fluid or air flush methods shall be used to reduce the potential for disturbance to surrounding soils. External flush or wash methods for advancement of casing shall not be used.
- C. Contractor shall observe the ground conditions continuously during micropile installation for signs of ground heave, ground subsidence or loss of drill fluids. Immediately notify the Architect and Owner's Representative if signs are observed. Contractor shall immediately suspend or modify drilling or grouting operations if signs are observed, or if adjacent structures are damaged from the drilling or grouting. Contractor shall take corrective actions necessary to prevent further damage and perform repairs.

- D. Drilling shall be made in such a manner to prevent loss of ground beyond the specified pile diameter. Drilling mud or other methods shall be employed as required to stabilize the hole and prevent loss of ground. Drilling mud in the hole shall be sufficiently fluid such that it is readily and fully displaced by the cement grout.
- E. Drilling equipment and methods shall permit the advancement of casing through materials encountered and in a manner which will not loosen the materials below the pile cap around the casing. Intimate contact between the casing and the adjacent materials shall exist after the casing is installed.
- F. The bottom tip of the casing shall include carbide teeth to facilitate the casing being drilled through boulders and into rock. The roller bit shall be operated within the casing to direct water or air flush up through the casing rather than ahead and outside the casing circumference.
- G. A down-the-hole hammer or other approved methods shall be used only after the casing tip has reached a minimum depth of 2 ft into rock except down-the-hole hammer systems may be used above this depth provided the materials and tooling is specially designed to direct primary air flush up through the inside of the casing and remove material in front of the drill with a minor amount of air flush across the drill face. These specially designed tool systems include, but is not limited to, the Spiral Flush system manufactured by Mincon.
- H. Excavation and drilling spoils shall be controlled to minimize disturbances to site conditions and hindrances to pile installation procedures and requirements. The drilling water, spoil or other resulting by-products shall not be allowed to enter into any municipal drainage system without prior written approval from the controlling agency and the Owner.
- I. The Contractor is responsible for controlling the amount of dust and dirt created by the pile installation process using whatever methods are most appropriate.
- J. Pile locations shall be checked during installation and appropriate measures taken as necessary to maintain the correct pile location.
- K. Each pile shall be drilled to achieve the support within the identified bearing strata and shall be capable of supporting the specified design load. The bedrock socket shall be formed in tan, red, and/or gray, residual metasedimentary disintegrated rock with a Standard Penetration Test (SPT) resistance (N-value) of no less than 60 blows per foot.
- L. After drilling the rock socket, the hole shall be flushed with water and/or air to remove drill cuttings and/or other debris. Flush and re-flush as required until clear visibility through the drill fluid is obtained to complete the downhole video inspection.
- M. Casing joints shall be completely shouldered. Reinforcement shall be fully threaded into stop-type couplers with hex nuts.
- N. The reinforcement shall be lowered in the cased hole without difficulty. Provide centralizers equally spaced along the length of the reinforcement with a maximum center-to-center spacing of 10 ft. Locate the center of the bottom centralizer 3 ft (+/-1 ft) from the bottom of the micropile. Located the center of the top (after final cut-off) centralizer within 5 ft below the final cut-off elevation. Centralizers shall be located at least 2 ft from reinforcement couplers. Provide at least two centralizers per micropile. For micropiles 20 ft or less in length, place centralizers at the top and bottom quarter points of the micropile. Centralizers shall be

fabricated and installed to permit the free flow of grout without misalignment of the steel components. Lower the reinforcement with centralizers into the casing. Redrill casing and reinsert reinforcement if any difficulty is encountered during gravity lowering of the reinforcement.

O. Grouting:

1. The Contractor shall provide a stable, homogenous neat cement grout or a sand cement grout with a minimum 28-day unconfined compressive strength shown on the Drawings.
2. The grout shall not contain lumps or any other evidence of poor or incomplete mixing.
3. Grout of the specified compressive strength shall be placed by means of a tremie pipe and grout pump from the bottom of the pile upward in one continuous operation until the pile is filled and suitable, undiluted cement grout returns at the top of the pile. The cement grout shall not be allowed to fall freely through slurry or water.

3.3 PILE REJECTION

- A. Piles which are believed to have collapsed, based on the grout take volume, or which are otherwise unsatisfactory as specified above and which cannot be removed or repaired, will be rejected and shall be abandoned and filled with cement grout.
- B. Piles that are rejected as judged by the Architect because of damage, mis-location or misalignment, or failure to meet other installation criteria, shall be cut off below the design cut-off grade and abandoned. Additional pile(s) shall be installed as necessary subject to review by the Architect. Whenever, in the judgment of the Architect, misalignment or rejection of a pile is caused by the Contractor's non-conformance or other error on the Contractor's part, and installation of one or more replacement piles is necessitated, the cost of such re-installation shall be borne by the Contractor.

3.4 DISPOSAL OF EXCAVATED MATERIAL

- A. Excavated and cut-off pile material shall be removed and legally disposed of off-site by the Contractor in accordance with all applicable Sections. Prior to drill water discharge, the excess water shall pass through a sedimentation basin to remove soil fines. Additional treatment of water or slurry shall be performed as necessary to comply with any and all permits issued for dewatering and discharging of water and with all applicable regulatory requirements.

PART 4 - MEASUREMENT AND PAYMENT

4.1 GENERAL

- A. Pile installation includes all services, engineering, permits, labor, equipment, transportation, material, and supplies to complete the work herein. Payment for these items shall include furnishing, installing, grouting, testing, instrumentation, engineering, mobilization and demobilization, and other items incidental to the work specified herein. No other payments for any specified or indicated work nor for any work implied therefrom shall be made.
- B. Additions and/or deductions in the total footage may result during the course of the Work either by changes in pile length or changes in the number of piles. Total footage of micropiles added to or deleted from the Contract by the Owner will be measured and paid/credited on a per linear foot basis. The Contractor will be paid for additional length of micropiles at the Contract unit price when the length shown on the Drawings has been deepened by the Architect. Should a

design change be implemented by the Architect that results in a shortening of a micropile, a credit (at the Contract unit price) will be due the Owner for footage less than that indicated on the Drawings. The Contractor will not be compensated for micropiles that bear deeper than design elevations due to disturbance of the rock socket by the Contractor's activities and/or other unauthorized deepening of micropile lengths.

- C. Additions to the number of pile load tests may results during the course of the Work if directed by the Architect. Additional pile load testing added to the Contract by the Owner will be measured and paid/credited on a per test basis. The per test basis shall include the sacrificial pile on which the test will be performed and load testing on each pile shall be in accordance with the methods in this Section.
- D. No separate measurement or payment will be made for removing or overcoming obstructions.
- E. No separate measurement or payment will be made for rejected (or additional piles caused by rejected) piles or pile load tests due to the Contractor's non-conformance with project requirements or other Contractor error.
- F. Whenever, in the judgment of the Architect, misalignment or rejection of a pile or piles, caused by the Contractor's non-conformance with the specification or other Contractor error, necessitates structural redesign, the cost of such redesign shall be deducted from sums otherwise due to the Contractor under the contract. If the redesigned structural shoring requires greater quantities of materials, as compared with the quantities required as originally designed, the additional costs shall also be deducted from the contract price.

4.2 MEASUREMENT AND PAYMENT

- A. Payment for micropile installation measured and computed as provided above, will be made as part of the Base Contract Price, all-inclusive basis for the furnishing of all material, mobilization, labor, equipment, tools, and incidentals necessary to complete the Work specified herein and shown on the Drawings. No separate measurement or payment will be made for acquisition of permits, backfill, pre-excavation, equipment, material disposal, slurry, police details, water, electricity, material handling and re-handling, pile load tests, engineering, surveying, steel reinforcement, concrete, removal of steel and/or sound concrete to the design top of micropile elevation, chipping or chiseling contaminated (unsound) concrete to sound concrete and re-pouring concrete to the design top of micropile elevation, or other associated items or work considered incidental to the conduct of micropile construction.
- B. Payment for the work of this Section shall be a lump sum (Base Contract Price) covering all costs for the micropile work and incidentals as called for on the Drawings and in this Section except:
 - 1. Additional footage of micropiles shown on the Drawings added to the Contract by the Owner will be paid on a unit price basis.
 - 2. Reduced footage of micropiles shown on the Drawings deducted from the Contract by the Owner will be credited to the Owner on a unit price basis.
 - 3. Additional load tests of micropiles shown on the Drawings added to the Contract by the Owner will be paid on a unit price basis.

<u>Item No.</u>	<u>Description</u>	<u>Unit</u>
316333-1	Additional footage of micropile	\$____/ foot
316333-2	Reduced footage of micropile	\$____/ foot
316333-3	Additional sacrificial micropile and pile load test for compression and tension allowable loads	\$____/ each
316333-4	Additional sacrificial micropile and pile load test for lateral allowable loads	\$____/ each

END OF SECTION 316333

FOR REFERENCE ONLY

June 15, 2026

**Smithsonian OPDC Project No. 2533105
SmithGroup Project No. 00100084**

THIS PAGE INTENTIONALLY LEFT BLANK

FOR REFERENCE ONLY

SECTION 32 1313 – CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Sections includes the following:
 - 1. Aggregate base course.
 - 2. Concrete paving for:
 - a. Concrete sidewalks
 - b. Concrete curbs and gutters
- B. Related Requirements:
 - 1. Section 321373 – Concrete Paving Joint Sealants

1.2 REFERENCES

- A. American Concrete Institute:
 - 1. ACI 301 – Specifications for Structural Concrete.
 - 2. ACI 304 – Guide for Measuring, Mixing, Transporting, and Placing Concrete.
- B. ASTM International:
 - 1. ASTM A185/A185M – Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
 - 2. ASTM A497/A497M – Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.
 - 3. ASTM A775/A775M – Standard Specification for Epoxy-Coated Steel Reinforcing Bars.
 - 4. ASTM A884/A884M – Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement.
 - 5. ASTM A934/A934M – Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.
 - 6. ASTM C31/C31M – Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 7. ASTM C33 – Standard Specification for Concrete Aggregates.
 - 8. ASTM C39/C39M – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
 - 9. ASTM C94/C94M – Standard Specification for Ready-Mixed Concrete.
 - 10. ASTM C143/C143M – Standard Test Method for Slump of Hydraulic Cement Concrete.
 - 11. ASTM C150 – Standard Specification for Portland Cement.
 - 12. ASTM C172 – Standard Practice for Sampling Freshly Mixed Concrete.
 - 13. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.
 - 14. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
 - 15. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
 - 16. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - 17. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
 - 18. ASTM C595 - Standard Specification for Blended Hydraulic Cements.
 - 19. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
 - 20. ASTM C989 - Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.

21. ASTM C1017/C1017M - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
22. ASTM C1064/C1064M - Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete.
23. ASTM C1116 - Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
24. ASTM C1315 - Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
25. ASTM C1371-2004a - Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers.
26. ASTM C1549-2004 - Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer.
27. ASTM E408-1971(1996)e1 - Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques.
28. ASTM E903-1996 - Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres.
29. ASTM E1918-1997 - Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field.
30. ASTM E1980-2001 - Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

C. District Department of Transportation (DDOT):

1. Standard Specifications for Highways and Structures.

1.3 PRE-INSTALLATION MEETINGS

A. Section 013000 – Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.4 SUBMITTALS

A. Section 013300 – Submittal Procedures: Requirements for submittals.

B. Product Data:

1. Submit data on all concrete materials, including admixtures and curing compounds.

C. Design Data:

1. Submit concrete mix design for each concrete strength. Submit separate mix designs when admixtures are required for the following:
 - a. Hot and cold weather concrete work.
2. Identify mix ingredients and proportions, including admixtures.
3. Identify chloride content of admixtures and whether chloride was added during manufacture.

D. Source Quality Control Submittals: Include results of factory tests and inspections.

1. Aggregate Tests
2. Concrete slump Tests
3. Air Content Tests
4. Flexural Strength Tests
5. Cementitious Materials
6. Field quality-control reports

1.5 SUSTAINABLE DESIGN SUBMITTALS

- A. Section 018113 – Sustainable Design Requirements: Requirements for sustainable design submittals.
- B. Manufacturer's Certificate: Certify products meet or exceed specified sustainable design requirements.
 - 1. Sustainable Sites Certificates:
 - a. Certify paving materials solar reflectance index.
 - 2. Materials Resources Certificates:
 - a. Certify recycled material content for recycled content products.
 - b. Certify source for regional materials and distance from Project site.
- C. Product Cost Data: Submit cost of products to verify compliance with Project sustainable design requirements. Exclude cost of labor and equipment to install products.
 - 1. Provide cost data for the following products:
 - a. Products with recycled material content.
 - b. Regional products.

1.6 QUALITY ASSURANCE

- A. Perform Work according to ACI 301 requirements of Section 031000, Section 032000, and Section 033000.
- B. Obtain cementitious materials from same source throughout.
- C. Perform Work according to DDOT standards.
- D. Maintain one copy of each document on site.

1.7 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum three years documented experience.

1.8 AMBIENT CONDITIONS

- A. Section 015000 – Temporary Facilities and Controls: Ambient conditions control facilities for product storage and installation.
- B. Do not place concrete when base surface temperature is less than 40 degrees F, or surface is wet or frozen.

PART 2 - PRODUCTS

2.1 SUSTAINABILITY CHARACTERISTICS

- A. Section 018113 – Sustainable Design Requirements: Requirements for sustainable design compliance.

2.2 AGGREGATE BASE COURSE

- A. Aggregate Base Course: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 209 Aggregate Base Course.

2.3 CONCRETE PAVING

- A. Performance/Design Criteria:
 - 1. Paving: Refer to Pavement Cross Section details provided in the Contract Drawings.
- B. Form Materials:
 - 1. Form Materials: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.06 Setting Forms.
- C. Reinforcement:
 - 1. Reinforcing Steel and Wire Fabric: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 812.01 Welded Wire Fabric.
- D. Sidewalk Concrete Materials:
 - 1. Cement: ASTM C150, Type I/II, no supplements such as Fly Ash or Granulated Blast Furnace Slug permitted. Refer to Landscape Drawings for color.
 - 2. Fine and Coarse Aggregates: Coarse aggregates shall be gravel of normal weight and uniformly graded from a single source with nominal maximum size of ¾-inch. Fine aggregates must be free of materials with deleterious reactivity to alkali in cement.
 - 3. Water: ASTM C94/C94M potable, without deleterious amounts of chloride ions.
 - 4. Air Entraining Admixture must meet ASTM C94; percent entrained air shall be 5 to 8 percent by volume.
 - 5. Chemical Admixtures – Compatible with other admixtures and manufacturer certified and to contain no more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
- E. Curb and Gutter Concrete Materials:
 - 1. Adhere to the requirements set forth in DDOT Standard Specifications for Highways and Structures, Section 606.01.
 - 2. Materials: Shall meet the requirements specified in DDOT Standard Specifications for Highways and Structures, Section 501.02, except the Portland Cement Concrete (PCC) shall be Class F.
 - 3. Consistency: The consistency of the PCC shall meet the requirements specified in DDOT Standard Specifications for Highways and Structures, Section 501.15.

2.4 MIXES

- A. Concrete Mix – The proportions of materials for concrete shall meet the requirements of DDOT Standard Specifications for Highways and Structures, Section 817, Class F.

2.5 FINISHES

- A. Welded Wire Fabric: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 812.01 Welded Wire Fabric.

2.6 ACCESSORIES

- A. Curing Compound: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 814.01.
- B. Liquid Membrane Curing Compound: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 814.02.
- C. Air Entraining Admixtures: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 814.03.
- D. Chemical Admixtures: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 814.04.

2.7 SOURCE QUALITY CONTROL

- A. Section 014000 – Quality Requirements: Testing and Inspection Services: Provide mix design for Sidewalk and Concrete Curb and Gutter.
- B. Submit proposed mix design of each class of concrete for review prior to commencement of Work.
- C. Tests on cement, aggregates, and mixes will be performed to ensure conformance with specified requirements.
- D. Test samples according to ASTM C94/C94M and ACI 301.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 017000 – Execution and Closeout Requirements: Requirements for installation examination.
- B. Verify compacted subgrade is dry and ready to support paving and imposed loads.
 - 1. Proof roll subgrade according to DDOT Standard Specifications for Highways and Structures, Section 203.03.
- C. Verify gradients and elevations of base subgrade are correct.

3.2 PREPARATION

- A. Section 017000 – Execution and Closeout Requirements: Requirements for installation examination.
- B. Moisten substrate to minimize absorption of water from fresh concrete.

- C. Coat surfaces of manholes and inlet frames with oil to prevent bond with concrete paving. Ensure oil does not negatively react with the concrete, alter any surface finishes or colors, and conforms to the District Department of Energy and Environment (DOEE) environmental laws.
- D. Notify Contracting Officer Technical Representative (COTR) minimum 24 hours prior to commencement of concreting operations.

3.3 INSTALLATION

- A. Aggregate Base Course: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 209 Aggregate Base Course.
- B. Forms: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.06 Setting Forms.
- C. Reinforcement: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.12 and Manufacturer Requirements.
- D. Placing Concrete: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.11 Placing and Consolidating Concrete.
- E. Finishing: Follow the Manufacturer Requirements.
- F. Curing and Protection: Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.17 Curing.

3.4 TOLERANCES

- A. Section 014000 – Quality Requirements: Tolerances.
- B. Follow the requirements noted in the DDOT Standard Specifications for Highways and Structures, Section 501.23 Tolerance in Pavement Thickness.

3.5 FIELD QUALITY CONTROL

- A. Section 014000 – Quality Requirements: Requirements for testing, adjusting, and balancing.
- B. Perform field testing according to the requirements of the DDOT Standard Specifications for Highways and Structures.
- C. Inspect reinforcing placement for size, spacing, location, and support.
- D. Testing firm will take cylinders and perform slump and air entrainment tests according to ACI 301.
- E. Strength Test Samples:
 - 1. Sampling Procedures: ASTM C172
 - 2. Cylinder Molding and Curing Procedures: ASTM C31/C31M, cylinder specimens, field cured.
 - 3. Sample concrete and make one set of three cylinders for every 150 cubic yards or less of each class of concrete placed each day and for every 5,000 square feet of surface area paving.
 - 4. Make one additional cylinder during cold weather concreting, and field cure.

F. Field Testing:

1. Slump Test Method: ASTM C143/C143M.
2. Air Content Test Method: ASTM C173/C173M or ASTM C231.
3. Temperature Test Method: ASTM C1064/C1064M.
4. Measure slump and temperature for each compressive strength concrete sample.
5. Measure air content in air entrained concrete for each compressive strength concrete sample.

G. Cylinder Compressive Strength Testing:

1. Test Method: ASTM C39/C39M.
2. Test Acceptance: Follow the testing according to the requirements of the DDOT Standard Specifications for Highways and Structures.
3. Test one cylinder at 7 days.
4. Test two cylinders at 28 days.
5. Dispose remaining cylinders when testing is not required.

H. Maintain records of placed concrete items. Record date, location of pour, quantity, air temperature, and test samples taken.

3.6 PROTECTION

- A. Section 017000 – Execution and Closeout Requirements: Requirements for protecting finished Work.
- B. Immediately after placement, protect paving from premature drying, excessive hot or cold temperatures, and mechanical injury.
- C. Do not permit pedestrian or vehicular traffic over paving for 7 days minimum after finishing or until 75% percent design strength of concrete has been achieved, whichever occurs last.

END OF SECTION

SECTION 32 1313 - CONCRETE PAVING**PART 1 GENERAL****1.1 RELATED REQUIREMENTS**

- A. Section 03 1000 - Concrete Forming and Accessories.
- B. Section 03 2000 - Concrete Reinforcing.
- C. Section 03 3533 - Stamped Concrete Finishes: Additional requirements for patterned surfaces.
- D. Section 07 9200 - Joint Sealants: Sealing joints.
- E. Section 31 2200 - Grading: Preparation of site for paving and base and preparation of subsoil at pavement perimeter for planting.
- F. Section 32 1120 - Subbase and Aggregate Base Courses.

1.2 REFERENCE STANDARDS

- A. ACI PRC-211.1 - Selecting Proportions for Normal-Density and High Density-Concrete - Guide; 2022.
- B. ACI PRC-304 - Guide for Measuring, Mixing, Transporting, and Placing Concrete; 2000 (Reapproved 2009).
- C. ACI PRC-305 - Guide to Hot Weather Concreting; 2020.
- D. ACI PRC-306 - Guide to Cold Weather Concreting; 2016.
- E. ACI SPEC-301 - Specifications for Concrete Construction; 2020.
- F. ASTM C33/C33M - Standard Specification for Concrete Aggregates; 2024a.
- G. ASTM C39/C39M - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens; 2024.
- H. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete; 2026.
- I. ASTM C150/C150M - Standard Specification for Portland Cement; 2024.
- J. ASTM C173/C173M - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method; 2026.
- K. ASTM C260/C260M - Standard Specification for Air-Entraining Admixtures for Concrete; 2024.
- L. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete; 2024.
- M. ASTM C618 - Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete; 2025a.

1.3 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on joint filler, admixtures, and curing compound.
- C. Samples: Submit One of each paving type sample panels, 36 BY 36 inch (____ by ____ mm) in size illustrating finish.

PART 2 PRODUCTS**2.1 FORM MATERIALS**

- A. Form Materials: As specified in Section 03 1000, comply with ACI SPEC-301.

2.2 REINFORCEMENT**2.3 CONCRETE MATERIALS**

- A. Obtain cementitious materials from same source throughout.
- B. Exposed Aggregate: Quartz washed natural mineral aggregate, ____ inch (____ mm) minimum and ____ inch (____ mm) maximum size, _____ color, from a single source.
- C. Fly Ash: ASTM C618, Class C or F.
- D. Calcined Pozzolan: ASTM C618, Class N.
- E. Silica Fume: ACI PRC-211.1.
- F. Water: Clean, and not detrimental to concrete.
- G. Fiber Reinforcement: Synthetic fibers shown to have long-term resistance to deterioration when in contact with alkalis and moisture; 1/2 inch (12 mm) length.
- H. Air-Entraining Admixtures: ASTM C260/C260M.
- I. Chemical Admixtures: ASTM C494/C494M, Type A - Water Reducing, Type C - Accelerating, and Type G - Water Reducing, High Range and Retarding.

2.4 ACCESSORIES

- A. Surface Retarder:

2.5 CONCRETE MIX DESIGN

- A. Proportioning Normal Weight Concrete: Comply with ACI PRC-211.1 recommendations.
- B. Admixtures: Add acceptable admixtures as recommended in ACI PRC-211.1 and at rates recommended by manufacturer.
- C. Fiber Reinforcement: Add to mix at rate of 1.5 pounds per cubic yard (0.89 kg per cubic meter), or as recommended by manufacturer for specific project conditions.
- D. Concrete Properties:
 - 1. Compressive strength, when tested in accordance with ASTM C39/C39M at 28 days; ____ psi (____ MPa).
 - 2. Fly Ash Content: Maximum 15 percent of cementitious materials by weight.
 - 3. Calcined Pozzolan Content: Maximum 10 percent of cementitious materials by weight.
 - 4. Silica Fume Content: Maximum 5 percent of cementitious materials by weight.
 - 5. Total Air Content: 4 percent, determined in accordance with ASTM C173/C173M.

2.6 MIXING**PART 3 EXECUTION****3.1 EXAMINATION**

- A. Verify compacted subgrade is acceptable and ready to support paving and imposed loads.
- B. Verify gradients and elevations of base are correct.

3.2 SUBBASE

- A. See Section 32 1120 for construction of base course for work of this Section.

3.3 PREPARATION

- A. Moisten base to minimize absorption of water from fresh concrete.

3.4 FORMING

- A. Place and secure forms to correct location, dimension, profile, and gradient.

3.5 REINFORCEMENT

- A. Place reinforcement as indicated.

3.6 COLD AND HOT WEATHER CONCRETING

- A. Follow recommendations of ACI PRC-305 when concreting during hot weather.
- B. Follow recommendations of ACI PRC-306 when concreting during cold weather.
- C. Do not place concrete when base surface temperature is less than 40 degrees F (4 degrees C), or surface is wet or frozen.

3.7 PLACING CONCRETE

- A. Place concrete in accordance with ACI PRC-304.
- B. Ensure reinforcement, inserts, embedded parts, formed joints and ____ are not disturbed during concrete placement.

3.8 JOINTS

- A. Align joints with adjacent surfaces.
- B. Provide scored joints.

3.9 EXPOSED AGGREGATE

3.10 FINISHING

- A. Area Paving: Light broom, texture perpendicular to pavement direction.

3.11 TOLERANCES

- A. Maximum Variation of Surface Flatness: 1/4 inch (6 mm) in 10 ft (3 m).

3.12 FIELD QUALITY CONTROL

- A. An independent testing agency will perform field quality control tests, as specified in Section 01 4000 - Quality Requirements.
 - 1. Provide free access to concrete operations at project site and cooperate with appointed firm.
 - 2. Submit proposed mix design of each class of concrete to inspection and testing firm for review prior to commencement of concrete operations.

3.13 PROTECTION

- A. Immediately after placement, protect pavement from premature drying, excessive hot or cold temperatures, and mechanical injury.

END OF SECTION

SECTION 32 1316 - DECORATIVE CONCRETE PAVING**PART 1 - GENERAL****1.1 SUMMARY**

- A. Section includes colored and stained concrete paving.
- B. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for general building applications of concrete.
 - 2. Section 32 1373 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within decorative concrete paving and in joints between decorative concrete paving and other paving or adjacent construction.

1.2 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.
- C. Carbon Dioxide Mineralization: Active carbonation treatment of concrete during mixing such that the carbon dioxide (CO₂) that is injected during mixing is mineralized (I.E.chemically converted into a mineral) within the concrete. The concrete may undergo mix optimization whereby the strength enhancement property of the mineralized CO₂ is utilized to adjust cementitious content, pending that the optimized concrete mix meets concrete performance requirements as outlined.
- D. Carbonization Treatment: Active introduction of CO₂ into the concrete pore fluid which reacts with calcium from calcium hydroxide and calcium silicate hydrate to form calcite (CaCO₃).

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.
 - 1. Review methods and procedures related to decorative concrete paving, including but not limited to, the following:
 - a. Concrete mixture design.
 - b. Quality control of concrete materials and decorative concrete paving construction practices.
 - c. Mockup schedule.
 - d. Installation schedule.
 - e. Site access logistics.
 - f. Curing procedures.
 - g. Cold and hot weather concreting procedures.
 - h. Global warming potential (GWP) limits.
 - 2. Require representatives of each entity directly concerned with decorative concrete paving to attend, including the following:
 - a. Contractor's superintendent.
 - b. Ready-mix concrete manufacturer.
 - c. Decorative concrete paving Installer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer ready-mix concrete manufacturer.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Steel reinforcement and reinforcement accessories.
 - 3. Fiber reinforcement.
 - 4. Admixtures.
 - 5. Curing compounds.
 - 6. Applied finish materials.
 - 7. Bonding agent or epoxy adhesive.
 - 8. Joint fillers.
 - 9. Repair materials
- C. Material Test Reports: For each of the following:
 - 1. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- D. Field quality-control reports.
- E. Mix Design: Submit Mix design for each type of decorative concrete paving.
- F. Product Test Reports and Certificates: For each of the following, signed by manufacturers:
 - 1. Carbon dioxide mineralization: Provide concrete producers certificate verifying mineralization of carbon dioxide. Include quantity, location, and supplier of injected CO₂.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.
- B. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- C. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
- D. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 - 1. Build mockups of full-thickness sections of decorative concrete paving to demonstrate typical joints; surface color, pattern, and texture; curing; and standard of workmanship.

2. Build mockups of decorative concrete paving types in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than [96 inches (2400 mm) by 96 inches (2400 mm)].
 - a. One mockup for Integral Colored Concrete Pavement with Exposed Aggregate Surface
 - b. One mockup for Integral Colored Concrete Pavement, with color to match or complement existing concrete at Asia Trail
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
5. Provide a minimum of 3 mockups of each type of paving, with more as needed to obtain approval from the COTR or their representative.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on decorative concrete paving mixtures.

1.8 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
 2. Do not use frozen materials or materials containing ice or snow.
 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:
 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 - 1. Use flexible or uniformly curved forms for curves of a radius of 100 feet (30.5 m) or less. Do not use notched and bent forms.
- B. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.
- C. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

- A. Recycled Content of Steel Products: Postconsumer recycled content plus one-half of preconsumer recycled content not less than 90 percent.
- B. Plain-Steel Welded-Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn steel wire into flat sheets.
- C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
- D. Joint Dowel Bars: ASTM A 615/A 615M, Grade 60 (Grade 420) plain-steel bars. Cut bars true to length with ends square and free of burrs.
- E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded-wire reinforcement, and dowels in place. Manufacture bar supports according to CRST's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

2.4 CONCRETE MATERIALS

- A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from single source, and obtain admixtures from single source from single manufacturer.
- B. Cementitious Materials: Materials conforming to the following are permitted.
 - 1. Portland Cement: ASTM C 150/C 150M, gray or white portland cement Type I, with integral color.

- C. Normal-Weight Aggregates: ASTM C 33/C 33M, Class 4S, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials.
 - 1. Maximum Coarse-Aggregate Size: 3/4 inch (19 mm) nominal.
 - 2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
- D. Air-Entraining Admixture: ASTM C 260/C 260M.
- E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
 - 1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A, colored.
 - 2. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D, colored.
- F. Color Pigment: ASTM C 979/C 979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, nonfading, and resistant to lime and other alkalis.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Butterfield Color.
 - b. Davis Colors.
 - c. MATCRETE Inc.
 - d. Scofield, L. M. Company.
 - e. Solomon Colors, Inc.
- G. Water: Complying with ASTM C1602.
- H. Colors: See landscape drawings for color and finish type.

2.5 CURING AND SEALING MATERIALS

- A. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advanced Surfaces Inc.; Skid Guard.
 - b. Bomanite Corporation; Sure Trak.
 - c. Bon Tool Co.; BonWay Gator Grip Slip Resistive Additive.
 - d. H&C Concrete Care Products; SharkGrip Slip Resistive Additive.
 - e. QC Construction Products; QC Sure Trak.
 - f. Vexcon Chemicals Inc.; Certi-Vex Grip.

2.6 RELATED MATERIALS

- A. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber in preformed strips.

- B. Bonding Agent: ASTM C 1059/C 1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Epoxy-Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
 - 1. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
- D. Polyethylene Film: ASTM D 4397, 1 mil (0.025 mm) thick, clear.

2.7 CONCRETE MIXTURES

- A. Obtain each color, size, type, and variety of concrete mixture from single manufacturer with resources to provide concrete of consistent quality in appearance and physical properties.
- B. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
- C. Drying shrinkage limit is percentage in change in length after 28 days of drying when tested as per ASTM C157 with 3 inches x 3 inches x 11 inches specimen moist cured 7 days prior to drying.
- D. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - 1. Air Content: 6 percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.
- E. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- F. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use water-reducing admixture water-reducing and retarding admixture water-reducing and accelerating admixture in concrete as required for placement and workability.
 - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- G. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.
- H. Concrete Mixtures: Normal-weight concrete.
 - 1. Compressive Strength (28 Days): 3500 psi (24.1 MPa).
 - 2. Maximum W/C Ratio at Point of Placement: 0.45.
 - 3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).

2.8 CONCRETE MIXING

- A. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For concrete batches of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For concrete batches larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph (5 km/h).
 - 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
 - 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of [1/2 inch (13 mm)] according to requirements in Section 31 2000 "Earth Moving."
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT INSTALLATION

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded-wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap to adjacent mats.

3.5 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Butt Joints: Use [bonding agent] [epoxy-bonding adhesive] at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 3. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of [50 feet (15.25 m)] unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated on drawings. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent decorative concrete paving:
1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - a. Tolerance: Ensure that sawed joints are within [3 inches (75 mm)] in both directions from centers of dowels.
 2. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch (6-mm) radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.6 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
- G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating joint devices.
- H. Screed paving surface with a straightedge and strike off.

- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

3.8 INTEGRALLY COLORED CONCRETE FINISH

- A. Integrally Colored Concrete Finish: After final floating, apply the following finish:
 1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

3.9 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

3.10 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 (ACI 117M) and as follows:
 1. Elevation: 3/4 inch (19 mm).
 2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
 3. Surface: Gap below 10-foot- (3-m-) long, unleveled straightedge not to exceed 1/2 inch (13 mm).
 4. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
 5. Vertical Alignment of Dowels: 1/4 inch (6 mm).
 6. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
 7. Joint Spacing: 3 inches (75 mm).
 8. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
 9. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172/C 172M shall be performed according to the following requirements:
 - 1. Testing Frequency: Obtain at least one composite sample for each 5000 sq. ft. (465 sq. m) or fraction thereof of each concrete mixture placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 - 2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
 - 3. Air Content: ASTM C 231/C 231M, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
 - 4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.
 - 5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 - 6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Decorative concrete paving will be considered defective if it does not pass tests and inspections.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

- I. Prepare test and inspection reports.

3.12 REPAIR AND PROTECTION

- A. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.
- C. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION

SECTION 32 1373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cold-applied joint sealants.
 - 2. Cold-applied, fuel-resistant joint sealants.
 - 3. Hot-applied, fuel-resistant joint sealants.
 - 4. Joint-sealant backer materials.
 - 5. Primers.
- B. Related Requirements:
 - 1. Section 07 9200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Joint sealant for Integral Colored Concrete Pavement with Exposed Aggregate
 - 2. Joint sealant for Integral Colored Concrete Pavement
 - 3. Joint sealant for existing asphalt pavers
 - 4. Joint sealant at rockwork edge
- B. Retain "Samples for Verification" Paragraph below if a color choice is available for joint-sealant types specified.
- C. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
- D. Paving-Joint-Sealant Schedule: Include the following information:
 - 1. Joint-sealant application, joint location, and designation.
 - 2. Joint-sealant manufacturer and product name.
 - 3. Joint-sealant formulation.
 - 4. Joint-sealant color.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Certificates: For each type of joint sealant and accessory.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.
- B. Product Testing: Test joint sealants using a qualified testing agency.

1.6 FIELD CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:
 - 1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F (5 deg C).
 - 2. When joint substrates are wet.
 - 3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
 - 4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS, GENERAL

- A. Compatibility: Provide colored joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

- A. Single-Component, Nonsag, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type NS.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crafcro Inc.; RoadSaver Silicone.
 - b. Dow Corning Corporation; 888.
 - c. Pecora Corporation; 301 NS.
- B. Single-Component, Self-Leveling, Silicone Joint Sealant: ASTM D 5893/D 5893M, Type SL.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crafcro Inc.; RoadSaver Silicone SL.
 - b. Dow Corning Corporation; 890-SL.
 - c. Pecora Corporation; 300 SL.
- C. Multicomponent, Nonsag, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade NS, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Meadows, W.R., Inc.; Pourthane NS.

- D. Single Component, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type S, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Meadows, W.R., Inc.; Pourthane SL.
- E. Multicomponent, Pourable, Urethane, Elastomeric Joint Sealant: ASTM C 920, Type M, Grade P, Class 25, for Use T.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pecora Corporation; Dynatred Dynatrol II-SG Urethane NR-200.

2.3 JOINT-SEALANT BACKER MATERIALS

- A. Joint-Sealant Backer Materials: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by joint-sealant manufacturer, based on field experience and laboratory testing.
- B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.
- C. Round Backer Rods for Cold-Applied Joint Sealants: ASTM D 5249, Type 3, of diameter and density required to control joint-sealant depth and prevent bottom-side adhesion of sealant.
- D. Backer Strips for Cold- and Hot-Applied Joint Sealants: ASTM D 5249; Type 2; of thickness and width required to control joint-sealant depth, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

2.4 PRIMERS

- A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine joints to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Cleaning of Joints: Before installing joint sealants, clean out joints immediately to comply with joint-sealant manufacturer's written instructions.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
- B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

3.3 INSTALLATION OF JOINT SEALANTS

- A. Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions.
- C. Install joint-sealant backings to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 1. Do not leave gaps between ends of joint-sealant backings.
 2. Do not stretch, twist, puncture, or tear joint-sealant backings.
 3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.
- D. Install joint sealants immediately following backing installation, using proven techniques that comply with the following:
 1. Place joint sealants so they fully contact joint substrates.
 2. Completely fill recesses in each joint configuration.
 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:
 1. Remove excess joint sealant from surfaces adjacent to joints.
 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING AND PROTECTION

- A. Clean off excess joint sealant as the Work progresses, by methods and with cleaning materials approved in writing by joint-sealant manufacturers.

- B. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.

END OF SECTION

FOR REFERENCE ONLY

SECTION 32 1400 - UNIT PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Asphalt-block pavers set in bituminous setting beds.
- B. Related Requirements:
 - 1. Section 31 2000 "Earthwork" for concrete base under unit pavers.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

- A. Product Data: For materials other than water and aggregates.
- B. Product Data: For the following:
 - 1. Pavers.
 - 2. Bituminous setting materials.
 - 3. Joint materials
- C. Samples for Initial Selection: For each type of unit paver indicated and the following:

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for unit pavers, indicating compliance with requirements.
 - 1. For solid interlocking paving units, include test data for freezing and thawing according to ASTM C 67.

1.5 QUALITY ASSURANCE

- A. [Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
 - 1. Build mockups of full-thickness sections of unit paving
 - 2. Build minimum of 3 mockups in the location and of the size indicated or, if not indicated, build mockups where directed by Architect and not less than [96 inches (2400 mm) by 96 inches (2400 mm)].
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
 - 5. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
- B. Store liquids in tightly closed containers protected from freezing.
- C. Store asphalt cement and other bituminous materials in tightly closed containers.

1.7 FIELD CONDITIONS

- A. Cold-Weather Protection: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen subgrade or setting beds. Remove and replace unit paver work damaged by frost or freezing.
- B. Protect unit pavers and aggregate during storage and construction against wetting by rain, snow or groundwater, and against soilage or intermixture with earth or other types of materials.
- C. Handle pavers to prevent chipping, breakage, soiling or other damage. Do not use pinch or wrecking bars without protecting edges of pavers with wood or other rigid materials. Lift with wide-belt type slings wherever possible; do not use wire rope or ropes containing tar or other substances which might cause staining. If required, use wood rollers and provide cushion at end of wood slide.
- D. Store pavers on wood skids or pallets. Place and stock skids and pavers to distribute weight evenly and to prevent breakage or cracking. Protect stored pavers from weather with waterproof non-staining covers or enclosures, but allow air to circulate around pavers.
- E. Weather Limitations for Bituminous Setting Bed:
 - 1. Install bituminous setting bed only when ambient temperature is above 40 deg F (4 deg C) and when base is dry.
 - 2. Apply asphalt adhesive only when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (2 deg C) for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.

2.2 ASPHALT-BLOCK PAVERS

- A. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D 312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to 3/8 inch (9.5 mm).
 - 1. Basis of Design:

- a. Hanover 8" Hexagonal Asphalt Block Paver, Matrix A80011, Ground Tudor Finish
- b. Hanover 8" x 8" Asphalt Block Paver, Matrix A80026, Ground Tudor Finish

2.3 CURBS AND EDGE RESTRAINTS

- A. Job-Built Concrete Edge Restraints: Comply with requirements in Section 03 3000 "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of 3000 psi (20 MPa).

2.4 ACCESSORIES

- A. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

2.5 AGGREGATE SETTING-BED MATERIALS

- A. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
- B. Polymeric Sand for Joints
 - 1. Provide sand of color needed to produce required joint color.

2.6 BITUMINOUS SETTING-BED MATERIALS

- A. Primer for Base: ASTM D 2028/D 2028M, cutback asphalt, grade as recommended by unit paver manufacturer.
- B. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.
- C. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.
- D. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075-mm) sieve.
- E. Polymeric Sand for Joints
 - 1. Provide sand of color needed to produce required joint color.

2.7 BITUMINOUS SETTING-BED MIX

- A. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate unless otherwise indicated. Heat mixture to 300 deg F (149 deg C).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces indicated to receive unit paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

- B. Where unit paving is to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
- C. Proceed with installation only after unsatisfactory conditions have been corrected[and waterproofing protection is in place].

3.2 PREPARATION

- A. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
- B. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.
- C. Proof-roll prepared subgrade according to requirements in Section 31 2000 "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

3.3 INSTALLATION, GENERAL

- A. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.
- B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
- C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
- D. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
- E. Joint Pattern: As indicated, or to continue existing pattern..
- F. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
 - 1. Provide joint filler at waterproofing that is turned up on vertical surfaces[unless otherwise indicated; where unfilled joints are indicated, provide temporary filler or protection until paver installation is complete].
- G. Tolerances: Do not exceed 1/32-inch (0.8-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 10 feet (3 mm in 3 m) from level, or indicated slope, for finished surface of paving.

- H. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints[unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete]. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 9200 "Joint Sealants."

3.4 BITUMINOUS SETTING-BED APPLICATIONS

- A. Apply primer to concrete slab or binder course immediately before placing setting bed.
- B. Prepare for setting-bed placement by locating 3/4-inch- (19-mm-) deep control bars approximately 11 feet (3.3 m) apart and parallel to one another, to serve as guides for striking board. Adjust bars to subgrades required for accurate setting of paving units to finished grades indicated.
- C. Place bituminous setting bed where indicated, in panels, by spreading bituminous material between control bars. Spread mix at a minimum temperature of 250 deg F (121 deg C). Strike setting bed smooth, firm, even, and not less than 3/4 inch (19 mm) thick. Add fresh bituminous material to low, porous spots after each pass of striking board. After each panel is completed, advance first control bar to next position in readiness for striking adjacent panels. Carefully fill depressions that remain after removing depth-control bars.
 - 1. Roll setting bed with power roller to a nominal depth of 3/4 inch (19 mm). Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to 185 deg F (85 deg C).
- D. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of 1/16 inch (1.6 mm). Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.
- E. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.
- F. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.

3.5 REPAIRING, POINTING, AND CLEANING

- A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

END OF SECTION

SECTION 32 1816.13 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Unitary synthetic poured rubber EPDM seamless surface.

1.2 DEFINITIONS

- A. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
- B. SBR: Styrene-butadiene rubber.

1.3 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: According to ASTM F 1292.
- B. Accessibility of Surface Systems: According to ASTM F 1951.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- C. Shop Drawings: For each playground surface system, include materials, plans, cross sections, drainage, installation, penetration details, and edge termination including border edge tiles. Include patterns made by varying colors of surfacing.
- D. Samples for Initial Selection: For each type of playground surface system indicated.
- E. Samples for Verification: For each type of playground surface system indicated.
 - 1. Minimum 1-quart (0.95-L) loose-fill surface sealed in a container.
 - 2. Minimum 6-by-6-inch (150-by-150-mm) Sample of [synthetic rubber seamless] [synthetic rubber tile] [synthetic, dual-density, rubber tile] surface.
 - 3. 6-inch (150-mm) long by full-size cross section of border edging.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Critical heights for playground surfaces and fall heights for equipment.
- B. Qualification Data: For qualified Installer.

- C. Product Certificates: For each type of unitary synthetic playground surface system, from manufacturer.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For playground surface system to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain playground surface system materials, including primers and binders, from single source from single manufacturer.
- C. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292; and ASTM F 1487.

1.8 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit playground surface system installation to be performed according to manufacturers' written instructions and warranty requirements.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 UNITARY SYNTHETIC SEAMLESS SURFACE

- A. Surface System: Poured-in-place, single-layer system. Provide manufacturer's standard thickness as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. No Fault Sport Group, LLC; Bonded Rubber Mulch.
 - 1) or SI-approved equal.
 - 2. Cushion Course: Manufacturer's standard blend of recycled SBR and EPDM rubber, particles forming an integral wearing course and cushion course, site mixed and applied.
 - 3. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
 - 4. Critical Height: 5 feet (1.5 m) .
 - 5. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.
 - 6. Color(s): As selected by Architect from manufacturer's full range.

- B. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, subgrade and substrate conditions, drainage, and other conditions affecting performance of the Work.
- B. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary playground surface system installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to playground surface system manufacturer's written requirements for cross-section profile.
 - 1. Concrete Substrates: Verify that substrates are dry, free from surface defects, and free of laitance, glaze, efflorescence, curing compounds, form-release agents, hardeners, dust, dirt, loose particles, grease, oil, and other contaminants incompatible with playground surface system or that may interfere with adhesive bond. Determine adhesion, dryness, and acidity characteristics by performing procedures recommended in writing by playground surface system manufacturer.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.
- B. Concrete Substrates: Provide sound surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with playground surface system.
 - 1. Repair unsatisfactory surfaces and fill holes and depressions.
 - 2. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through playground surface system.

3.3 INSTALLATION, GENERAL

- A. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

3.4 INSTALLATION OF SEAMLESS PLAYGROUND SURFACE SYSTEMS

- A. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface and impact-attenuating system of total thickness indicated.
 - 1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.

2. Poured Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
3. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
4. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with [no] [a minimum of] cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.

3.5 PROTECTION

- A. Seamless Systems: Prevent traffic over system for not less than 48 hours after installation.

END OF SECTION

FOR REFERENCE ONLY

SECTION 32 3100 - METAL FENCES AND GATES**PART 1 GENERAL****1.1 SECTION INCLUDES**

- A. Guest Barrier
- B. Guest Handrail
- C. Service Handrail
- D. On Habitat Handrail
- E. Plant Protection Barrier
- F. Gates

1.2 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 31 2316 - Excavation.
- C. Section 09 94 13 -Themed Finishes

1.3 SYSTEM DESCRIPTION:

- A. Delegated Design:
 - 1. The work of this section requires professional design services or certifications by a design professional employed by the fabricator, and who is not the Consultant.
 - 2. Complete the design of the doors, frames, panels, and connections.
 - 3. Maintain the general design concept shown.
 - 4. Do not change member sizes or alter profiles and alignment, except as outlined in the design processes of this section.
- B. Structural Systems Design:
 - 1. Structural Design:
 - a) Provide the structural engineering design for all barriers, posts, wire rope (cables), wire rope, mesh, and mesh connections hardware, the doors, frames, hardware, fixed panels, and all connections. Connection hardware for cables shall have an ultimate capacity of at least 1.4 times the breaking strength of the cable or as recommended by the hardware manufacturer, whichever is greater. Refer to drawing for limits on cable and mesh sag (drape) and reactions on the supporting structure.
 - b) Drawings and Calculations:
Provide complete design, calculations, and drawings, prepared and signed in accordance with pertinent provisions of division one of these Specifications.
 - c) Licensed Engineer:
Design drawings will be prepared, approved, signed and sealed by a Professional Engineer licensed in the jurisdiction in which the project will be constructed.
 - 2. General Design Loads:
Design all elements for the following loads:
 - a) Dead loads
 - b) Live loads due to guests and keeper staff,
 - c) Wind loads where applicable.
- C. Approvals and Permits:
 - 1. General:
Secure the approval of governmental agencies having jurisdiction prior to submitting for the Consultant's approval.

2. Building Permits:
Obtain all required permits and approvals for proposed systems.
- D. Performance Standards:
 1. Materials specified herein are intended to establish the standards of quality required for the Work of this Section.
 2. Provide appropriate documentation that all proposed materials meet the specific performance requirements specified below.
 3. All materials and/or completed fabrications must have a twenty (20) year structural service life.
 4. All materials must be capable of resisting the loads and all potential wear and abrasions inherent in their position within the completed exhibits.

1.4 REFERENCE STANDARDS

- A. ASTM A276/A276M - Standard Specification for Stainless Steel Bars and Shapes; 2025.
- B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2025a.
- C. ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments; 2024.
- D. CLFMI WLG 2445 - Wind Load Guide for the Selection of Line Post and Line Post Spacing; 2023.

1.5 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturer's data sheets on each product to be used, including:
 1. Preparation instructions and recommendations.
 2. Storage and handling requirements and recommendations.
 3. Installation methods.
- C. Design Drawings:
 1. Delegated Design:
 - a) Submit complete drawings accurately showing proposed all of the fabrications and equipment described in this section, prepared in accordance with the following provisions:
 - b) Verify materials selection and sizes.
 - c) Verify fabrication and connection details for the fabrications or suggest alternative connection details.
 - d) Design system utilizing the system components specified in Part 2 of this specification.
 - e) Revise drawings as required by the Owner and resubmit.
 2. Delegated Design Submittals:
 - a) Provide all submittals described in Section 01 33 23 as required for the work of this section.
 3. Design Notes and Calculations:
 - a) Submit design notes and calculations, signed and sealed by the Professional Engineer.
- D. Shop Drawings:
 1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
 2. Drawings shall show all members, and shop
 3. Provide templates for anchor and bolt installation by other trades.

4. No fabrication or work shall be commenced until shop drawings have been reviewed and returned to the contractor.
 5. Fabricate from reviewed drawings only.
 6. Provide engineered drawings stamped by a structural engineer licensed in the jurisdiction in which the project is located.
- E. Prototype:
1. Construct one full-sized prototype of each type of door and door operator system for review by the Consultant and Owner.
 2. Revise the shop drawings for final review, incorporating all requested modifications to the door and operator system.
 3. The approved prototype may be included in the finished work when constructed in accordance with the final shop drawings.
- F. Samples:
1. Provide a two-foot length or square piece of each type, size, finish, and grade of each specified material.
 2. Provide a sample of each piece of hardware specified.
- G. Manufacturer's Warranty.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Experienced with type of construction involved and materials and techniques specified with a minimum of five years of experience.

1.7 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.1 METAL

- A. Metal Surfaces, General:

For fabrication of the Work of this Section, which will be exposed to view, use only those materials which are smooth and free from surface blemishes including pitting, seam marks, roller marks, rolled trade names and roughness.

- B. Standards:

All materials shall comply with:

1. Steel plates, shapes, and bars: ASTM A36.
2. Steel plates to be bent or cold formed: ASTM A283, Grade C.
3. Steel tubing, hot-formed, welded, or seamless: ASTM A501.
4. Steel bars and bar-size shapes: ASTM A306, Grade 65, or ASTM A36.
5. Cold-finished steel bars: ASTM A108, grade as selected by the fabricator.
6. Cold-rolled carbon steel sheets: ASTM A336.
7. Galvanized carbon steel sheets: ASTM A526, with G90 zinc coating in accordance with ASTM A525.
8. Steel pipe: ASTM A53, type as selected, Grade A, black finish unless galvanizing is specified or required, Schedule 40 unless otherwise indicated.
9. Structural Steel Tubes: ASTM A-500, Grade B

2.2 GALVANIZING

- A. General:

Provide a zinc coating for all ferrous metal specified in this section, as follows:

1. ASTM A153 for galvanizing iron and steel hardware.
2. ASTM A123 for galvanizing rolled, pressed, and forged steel shapes, plates, bars, and strip 3 mm (1/8") thick and heavier.
3. ASTM A386 for galvanizing assembled steel products.
4. All galvanized work to be reformed true to line and level as required in shop before delivery to the job site.

B. Field Galvanizing Repair:

C. Use a high zinc dust content paint for re-galvanizing welds in galvanized steel, complying with MIL-P-21035.

1. Repair in accordance with applicable requirements of ASTM A780.
2. Products: "Galvicon" by Galvicon Corp., "Drygalv" by Anchor Brand Co., "Tot-Rust" (with aluminum color added) by Wilbur & Williams Co. or equal.

2.3 WIRE ROPE ASSEMBLIES

A. Cable Fittings

2.4 WOVEN WIRE MESH

A. Manufacturers and Installers:

1. A thru Z Consulting and Distributing, Tucson AZ, info@athruzconsulting.com, www.athruzcages.com, tel: (520) 434-8284
2. Nets Unlimited, Cave Creek AZ, www.netsunlimited.com, tel: (480) 515-1300

B. Hand woven stainless steel wire mesh.

1. Woven from 1/16 inch diameter stainless steel wire rope.
2. 2 inch by 2 inch mesh openings.
3. Black oxide finish

2.5 LACING BARS

A. General:

1. 1/2" diameter gal
2. Weld to post as shown on drawings
3. Paint to match posts

2.6 GUEST BARRIER

A. Posts and rails, powder coated Bronze

B. Wire Rope cable assembly

C. Woven Wire Mesh: 1"x1"

D. Handrail mounted to posts, powder coated Bronze, where indicated on drawings

2.7 GUEST HANDRAIL

A. Handrail, powder coated Bronze

B. Posts, powder coated Bronze

2.8 SERVICE HANDRAIL

A. Handrail, painted Black

B. Posts, painted Black

- 1.

2.9 ON HABITAT HANDRAIL

A. Posts, painted Bronze

- B. Handrail, painted Bronze

2.10 PLANT PROTECTION BARRIER

- A. Metal Stanchion 1-1/2" square, powder coated Bronze
- B. Double Cables, Bronze
- C. Provide clips for access as indicated in drawings

2.11 SINGLE SWING GATE

- A. Metal Frame Gate, powder coated Bronze
- B. Wire Rope cable assembly
- C. Woven Wire Mesh: 1"x1"

2.12 DOUBLE SWING GATES

- A. Metal Frame Gate, powder coated Bronze
- B. Wire Rope cable assembly
- C. Woven Wire Mesh: 1"x1"
 - 1. HARDWARE
 - a) General: All hardware to be colored bronze
 - b) Acceptable manufacturers:
 - 1) Richards Wilcox, www.rwhardware.com
 - 2) McKinney, www.mckinneyhinge.com
 - 3) Stanley, www.stanley.com
 - 4) McMaster-Carr, www.mcmaster.com
 - 5) Gringer, www.graniger.com
 - c) Gate Hinge:
 - 1) Closing: Manual
 - 2) Material: Steel. Galvanized. Epoxy painted.
 - 3) Products:
 - (a) McKinney 5 knuckle, Heavy weight, ball bearing hinges
 - (b) Model T4B 3386
 - d) Heavy Duty Lift-Off Hinges:
 - 1) Closing: Manual.
 - 2) Material: Steel. Galvanized. Epoxy painted.
 - 3) Products:
 - (a) McMaster-carr 1071A38
 - e) Gate Latches: Finished to match fence components.
 - 1) Mechanism: Gravity.
 - 2) Locking: Mechanical.
 - 3) Material: 302 Stainless Steel Powder coated.
 - 4) Lockable
 - 5) Products:
 - (a) McMaster Carr
 - (b) Model 1774A15
 - (c) Match finish of gate frames.
 - (d) Provide padlock staple on latch side of gate
 - f) Cane Bolt
 - 1) Mechanism: Gravity.
 - 2) Locking: Mechanical

- 3) Material: Stainless steel
- 4) Products:
 - (a) Richards Wilcox
 - (b) Model 0524.00023SS
 - (c) Provide keeper in
- 2. Hardware Groups
 - a) Guest Barrier Single Swing Gate
 - 1) HW Group 1
 - 2 ea Gate Hinge
 - 1 ea Gate Latch
 - b) Guest Barrier Double Swing Gate
 - 1) HW Group 2
 - 2 ea Gate Hinge, per leaf
 - 1 ea Gate Latch
 - 2 ea Cane Bolt
- 3. Design & fabrication
 - a) Design Parameters:
 - 1) Fabricate from materials in sizes to achieve the profiles and arrangements shown on the drawings:
 - 2) Design to withstand the loads specified in Part 1 of this section.
 - 3) Make necessary allowances for expansion and contraction and movement of structure the structure.
 - b) Quality:
 - 1) Conform to the Quality Assurance standards for this work.
 - 2) Use materials of size and thickness shown or, if not shown, of required size and thickness to produce strength and durability of connecting material in the finished product.
 - 3) Work to dimensions shown or accepted on the Shop Drawings, using proven details of fabrication and support.
 - 4) Use type of materials shown or specified for the various components of the Work.
 - 5) Form exposed Work true to line and level, with accurate angles and surfaces and with straight sharp edges.
 - 6) Ease the exposed edges to a radius of approximately 1/32" unless otherwise shown.
 - 7) Weld metal and plastic corners and seams continuously, complying with the recommendations of the standard specifications for this section.
 - 8) At exposed connections, grind exposed metal welds smooth and flush; match and blend with adjoining surfaces.
 - 9) Form exposed connections flush and smooth, using concealed fasteners wherever possible.
 - 10) Provide for anchorage of the type shown. Coordinate with supporting structure. Fabricate and space the anchoring devices to provide adequate support for intended use.
 - 11) Cut, reinforce, drill, and tap the work as indicated to receive finish hardware and similar items.
 - 12) Fabricate joints that will be exposed to weather in a manner to exclude water or provide weep holes to evacuate accumulated water.
 - c) Support Posts and Gate Frames:

- 1) Provide horizontal and vertical members as shown on the drawings and as required to form a rigid structure without sag or twist.
- 2) Weld all frame members continuously at all joints.
- 3) Close all open tube ends.
- 4) Connections:
 - (a) All internal connections fully welded.
 - (b) Provide bolted connections to adjacent frames, panels, or concrete.
- d) Fasteners:
 - 1) Provide fastener material matching the materials to be fastened except where specified otherwise.
 - 2) Provide fastener types and sizes appropriate for size and weight of materials to be fastened and as documented in the shop drawings.
 - 3) Except where otherwise specified provide the following fastener types:
 - (a) Hot dip galvanized, conforming to all standards of paragraph 2.01 and Finishes below.
 - (b) Stainless steel, type 302/304.
4. finishes
 - a) Shop finishes
 - 1) Shop finish all work of this section, except members or portions of members to be embedded in concrete or masonry, surfaces and edges to be field welded.
 - 2) Finish stainless steel work as specified in this section.
 - 3) Remove scale, rust, and other deleterious materials before applying shop coat.
 - 4) Clean off rust and loose mill scale in accordance with SSPC-SP-1.
 - 5) Remove oil, grease, and similar contaminants in accordance with SSPC-SP-1.
 - 6) Sand blast to near white metal in accordance with SSPC-SP-10 for ferrous metals to receive zinc rich polyamid epoxy primer.
 - 7) Ferrous metals to receive zinc rich polyamid epoxy primer require inspection by Owner prior to priming. Notify Owner 24 hours prior to prime coating.
 - 8) Immediately after surface preparation, brush or spray on primer in accordance with manufacturer's recommendations, and at a rate to provide the recommended dry film thickness.
 - 9) Use painting methods, which will result in full coverage of joints, corners, edges, and exposed surfaces.
 - 10) Apply one shop coat to fabricated metal items; except, apply two shop coats to surfaces inaccessible after assembly or erection. Change color of second coat to distinguish it from the first coat.
 - b) Galvanizing:
 - 1) Galvanize all ferrous steel following fabrication in compliance with the following specifications:
 - (a) ASTM A 153 for galvanizing iron and steel hardware.
 - (b) ASTM A 123 for galvanizing rolled, pressed, and forged steel shapes, plates, bars, and strip 3 mm (1/8") thick and heavier.
 - (c) ASTM A 386 for galvanizing assembled steel products.
 - (d) All galvanized work to be performed true to line and level as required in shop before delivery to the job site.
 - c) Stainless Steel:
 - 1) All stainless steel to be finished black or black vinyl coated.
 - d) Powder Coating:
 - 1) Shop powder coat all work of this section with a thermoset powder coat.

- 2) Use abrasive, mechanical, or chemical cleaning to remove deleterious materials before applying shop coat as appropriate for the material being cleaned.
- 3) Clean in accordance with SSPC-SP-1 Solvent Cleaning or other SSPC standard.
- 4) Apply powder coat to 60 to 80 minimum dry coating thickness as appropriate for powder and color to be applied.
- 5) Use coating methods, which will result in full coverage of joints, corners, edges, and exposed surfaces.
- 6) Apply in accordance with ASTM D3451-06 Standard Guide for Testing Coating Powders and Powder Coatings.
- e) Field Galvanizing Repair:
 - 1) Use a high zinc dust content paint for re-galvanizing welds in galvanized steel, complying with MIL-P-21035.
 - 2) Repair in accordance with applicable requirements of ASTM A780.
 - 3) Products:
 - 4) "Galvicon" by Galvicon Corp., "Drygalv" by Anchor Brand Co., "Tot-Rust" (with aluminum color added) by Wilbur & Williams Co. or equal.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

3.2 INSTALLATION

- A. General
 1. Set work accurately at the established lines and levels.
 2. Install in strict accordance with approved drawings and actual conditions, true and horizontal or perpendicular as the case may be, level and square with angles and edges parallel with related lines of the structure.
 3. Set support structures and frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set.
 4. Install gates and hardware in accordance with manufacturer's data, and as specified herein.
- B. Shop Drawings:
 1. Install the work of this Section in strict accordance with the reviewed Shop Drawings.
- C. Anchor Bolts:
 1. Properly locate and build into the connecting work.
 2. Preset bolts and anchors using templates or such other methods as may be required to locate the anchors and anchor bolts accurately.
- D. Loose Bearing and Leveling Plates:
 1. Provide loose bearing and leveling plates for steel items bearing on concrete construction, made flat, free from warps or twists, and of required thickness and bearing area.
 2. Drill plates to receive anchor bolts and for grouting as required.
- E. Fastening:
 1. General.
 - a) Provide malleable iron washers for heads and nuts, which bear on wood structural connections.
 - b) Provide steel washers for all metal and plastic connections.
 - c) Cut, drill, and tap units to receive hardware.

- d) Provide gate frames with integrally welded anchors for casting into concrete or masonry, and furnish inserts if units must be installed after concrete is placed.
- e) Space anchors 60 cm (24") on centers, except where shown otherwise on the drawings.
- 2. Hardware:
 - a) Manufactured Hardware:
Fasten to substrates and frames using stainless steel screws, and bolts, using the sizes as recommended by the hardware manufacturer.
 - b) Custom Hardware:
Fasten to substrates and frames as shown in the reviewed design and shop drawings.
- F. Cable Barriers:
 - 1. Install cables in accordance with manufacture's instructions and approved shop drawings.
 - 2. Set components plumb, level and rigid
 - 3. Welding:
 - a) Field weld components indicated on the Shop Drawings
 - b) Grind exposed welds smooth
 - 4. Tack welds prohibited on exposed surfaces
 - a) Conform to AWS D1.1/D1.1M
 - 5. Install cable hardware onto ends of cables using manufacture's supplied swaging equipment
 - 6. Terminate and tension cables in accordance with manufacturer's instructions.
 - 7. Tension cables to a minimum of 400 pounds each.
 - 8. Ensure that cables are parallel to each other and without kinks or sags
 - 9. Prevent contact of exterior aluminum and dissimilar metals by use of zinc rich paint, bituminous coating or non-absorptive gaskets.
 - 10. Paint all steel posts per 09 94 16.
- G. Gate Installation:
 - 1. Fit gates accurately in their respective frames.
 - 2. Clearances between gates and posts or frames shall vary from 9.6mm (3/8-inch) minimum to 3/4-inch maximum.

3.3 CLEANING

- A. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.
- B. Clean fence with mild household detergent and clean water rinse well.
- C. Touch up scratched surfaces using materials recommended by manufacturer. Match touched-up paint color to factory-applied finish.

3.4 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

END OF SECTION

SECTION 32 3300 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Seating.
 - 2. Trash receptacles.
- B. Related Requirements:
 - 1. Section 03 3000 "Cast-in-Place Concrete" for installing pipe sleeves cast installing anchor bolts cast in concrete footings.
 - 2. Section 31 2000 "Earthwork" for excavation for installing concrete footings.

1.2 ACTION SUBMITTALS

- A. Submittal Compliance Form: If Basis-of-Design products are provided, Submittal Compliance Form may be submitted in lieu of required Product Data submittal. Ensure compliance with requirements included in Section 01 3300 "Submittal Procedures."
- B. Product Data: For each type of product.
- C. Sustainable Design Submittals:
 - 1. Product Data: For recycled content, indicating postconsumer and preconsumer recycled content and cost.
- D. Samples: For each exposed product and for each color and texture specified.
- E. Samples for Initial Selection: For units with factory-applied finishes.
- F. Product Schedule: For site furnishings. Use same designations indicated on Drawings.

1.3 QUALITY ASSURANCE

- A. Provide the following upon request:
 - 1. Material Certificates: For site furnishings manufactured with preservative-treated wood.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For site furnishings to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Bench Replacement Slats: No fewer than two full-size units for each size indicated.
 - 2. Trash Receptacle Inner Containers: Five full-size units for each size indicated, but no fewer than two units.

PART 2 - PRODUCTS

2.1 SEATING : as indicated in landscape drawings.

2.2 TRASH RECEPTACLES : as indicated in landscape drawings.

2.3 MATERIALS

- A. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
1. Rolled or Cold-Finished Bars, Rods, and Wire: ASTM B211 (ASTM B211M).
 2. Extruded Bars, Rods, Wire, Profiles, and Tubes: ASTM B221 (ASTM B221M).
 3. Structural Pipe and Tube: ASTM B429/B429M.
 4. Sheet and Plate: ASTM B209 (ASTM B209M).
 5. Castings: ASTM B26/B26M.
- B. Steel and Iron: Free of surface blemishes and complying with the following:
1. Plates, Shapes, and Bars: ASTM A36/A36M.
 2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
 3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
 4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
 5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
 6. Perforated Metal: From steel sheet not less than 0.120-inch (3.0-mm) nominal thickness; manufacturer's standard perforation pattern.
 7. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F1267.
 8. Malleable-Iron Castings: ASTM A47/A47M, grade as recommended by fabricator for type of use intended.
 9. Gray-Iron Castings: ASTM A48/A48M, Class 200.
- C. Stainless Steel: Free of surface blemishes and complying with the following:
1. Sheet, Strip, Plate, and Flat Bars: ASTM A240/A240M or ASTM A666.
 2. Pipe: Schedule 40 steel pipe complying with ASTM A312/A312M.
 3. Tubing: ASTM A554.
- D. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.
1. Wood Species: Manufacturer's standard.
- E. Certified Wood: Wood products shall comply with requirements of ASTM D7612-10 (FSC, SFI, ATSM, CSA or PEFC certifications are acceptable).
- F. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and with manufacturer's standard finish.

- G. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
 - 1. Polyethylene: Fabricated from virgin plastic HDPE resin.
 - 2. Polyethylene with Recycled Content: Fabricated from HDPE and other resins with postconsumer recycled content plus one-half of preconsumer recycled content not less than 90 percent.
- H. Anchors, Fasteners, Fittings, and Hardware: Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
 - 1. Angle Anchors: For inconspicuously bolting legs of site furnishings to below-grade substrate; extent as indicated.
 - 2. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; extent as indicated on Drawings.
- I. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
 - 1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.
 - 2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.4 WOOD-PRESERVATIVE-TREATED MATERIALS

- A. Preservative Treatment: Pressure-treat wood according to AWP A U1, Use Category UC3b, and the following:
 - 1. Use preservative chemicals acceptable to authorities having jurisdiction and containing no arsenic or chromium. Use chemical formulations that do not bleed through or otherwise adversely affect finishes. Do not use colorants to distinguish treated materials from untreated materials.
 - 2. Kiln-dry lumber and plywood after treatment to a maximum moisture content, respectively, of 19 and 15 percent. Do not use materials that are warped or do not comply with requirements for untreated materials.

2.5 FABRICATION

- A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
- B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
- C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.

- D. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPAC M4 to cut surfaces.
- E. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
- F. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.6 GENERAL FINISH REQUIREMENTS

- A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.7 ALUMINUM FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.8 STEEL AND GALVANIZED-STEEL FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.
- B. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

2.9 IRON FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2.10 STAINLESS STEEL FINISHES

- A. Surface Preparation: Remove tool and die marks and stretch lines, or blend into finish.
- B. Polished Finishes: Grind and polish surfaces to produce uniform finish, free of cross scratches.
 1. Run directional finishes with long dimension of each piece.
 2. Directional Satin Finish: ASTM A480/A480M, No. 4.
 3. Dull Satin Finish: ASTM A480/A480M, No. 6.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
- B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
- C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.
- D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.
- E. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and 3/4 inch (19 mm) larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with , mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

END OF SECTION

SECTION 32 84 00 - LANDSCAPE IRRIGATION

PART 1 - GENERAL

1.01 SCOPE

- A. Furnish all labor, materials, supplies, equipment, tools and transportation, and perform all operations in connection with and reasonably incidental to the complete installation of the irrigation system, and guarantee/warranty as shown on the drawings, the installation details, and as specified herein.

1.02 ITEMS OF WORK INCLUDED

- A. Items of work specifically included are:
 - 1. Procurement of all applicable licenses, permits, and fees including payment of all development, plant investment, or any other fees and permits associated with the purchase and installation of the tap.
 - 2. Coordination of Utility Location. ("Call Before You Dig")
 - 3. Verification of existing static pressure and flow rate.
 - 4. Installation, connection of all sensors, and programming of irrigation controller.
 - 5. Installation and connection to irrigation central control system.
 - 6. Maintenance period.
 - 7. Sleeving for irrigation pipe and wire.

1.03 RELATED WORK

- A. Division 00 00 00 – Procurement and Contracting Requirements
 - 1. 00 01 15 – List of Drawing Sheets
- B. Division 01 00 00 – General Requirements
 - 1. 01 10 00 – Summary
 - 2. 01 11 00 – Summary of Work
 - 3. 01 33 23 – Shop Drawings, Product Data, and Samples
- C. Division 02 00 00 – Existing Conditions
- D. Division 32 82 00 – Irrigation Pumps
- E. Division 32 90 00 – Planting

1.04 SUBMITTALS

- A. Submit samples under provisions of Contract Documents
- B. Deliver four (4) copies of all required submittals to the Owners' Representative within fifteen (15) days from the date of the Notice to Proceed.
- C. Materials List: Include, pipe, fittings, mainline components, water emission components, control

system components and all other components needed to construct a fully operating automatic irrigation system. At a minimum include all components specifically identified on the irrigation drawings. Quantities of materials need not be included.

- D. Manufacturers' Data: Submit manufacturers' catalog cuts, specifications, and operating instructions for equipment shown on the materials list. Highlight specific items to be utilized for construction of the irrigation system.
- E. Shop Drawings: Submit shop drawings called for in the installation details. Show products required for proper installation, their relative locations, and critical dimensions. Note modifications to the installation detail.
- F. Project Record Drawings: Submit project record (As-Built) drawings to Owner prior to commencement of maintenance period per Contract Documents. Accurate and complete project record drawings will be required before the maintenance period begins.

1.05 RULES AND REGULATIONS

- A. Work and materials shall be in accordance with the latest edition of the National Electric Code, the Uniform Plumbing Code as published by the Western Plumbing Officials Association, and applicable laws and regulations of the governing authorities.
- B. When the contract documents call for materials or construction of a better quality or larger size than required by the above-mentioned rules and regulations, provide the quality and size required by the contract documents.
- C. If quantities are provided either in these specifications or on the drawings, these quantities are provided *for information only*. It is the Contractor's responsibility to determine the actual quantities of all material, equipment, and supplies required by the project and to complete an independent estimate of quantities and wastage.

1.06 TESTING

- A. Notify the Owners' Representative three (3) days in advance of any testing.
- B. Pressure Test:
 - 1. Pipelines jointed with rubber gaskets or threaded connections may be subjected to a pressure test at any time after partial completion of backfill. Pipelines jointed with solvent-welded PVC joints shall be allowed to cure a minimum of 24 hours before testing. Pipelines installed with thrust blocks shall have the concrete cured for a minimum of seven (7) days before testing.
 - 2. Subsections of mainline pipe may be tested independently, subject to the review of the Owners' Representative.
 - 3. Furnish clean, clear water, pumps, labor, fittings, and all equipment necessary to conduct tests or retests.
 - 4. The test pressure shall not exceed the rated working pressure of the pipe.
 - a. Hydrostatic Pressure Test:
 - 1) Fill mainline pipe with water, purge all air out of the system. Subject mainline pipe to a hydrostatic pressure of 150 PSI for two hours. Test with mainline components installed. A 2 PSI pressure variation is allowed.
 - a.) The use of an air compressor to provide pressure is not allowed.

- 2) Fill lateral pipe with water, purge all air out of the system. Subject lateral pipe to a hydrostatic pressure of 75 PSI. Test with risers for sprinklers capped.
 - a.) The use of an air compressor to provide pressure is not allowed.
- 3) Backfill to prevent pipe from moving under pressure. Expose couplings and fittings.
- 4) Leakage will be detected by visual inspection. Replace defective pipe, fitting, joint, valve, or appurtenance. Repeat the test until the pipe passes test.
 - a.) Cement or caulking to seal leaks is prohibited.
- 5) The Owners' Representative reserves the option to furnish the gauges and metering devices for the tests.

C. Operational Test:

1. Prior to the Operational Test connect and configure all system sensors.
 - a. The flow sensor shall be operational and operated per the manufacturer's instructions to learn the flow for all zones to be tested. The flow shall be stored in the controller's memory.
 - b. The master valve shall be installed and connected to the controller, and fully operational.
 - c. All rain, wind, temperature, weather or other sensors specified on the plan shall be installed, connected, and fully operational.
2. Activate each remote-control valve in sequence from controller. The Owners' Representative will visually observe operation, water application patterns, and leakage.
3. Replace defective remote-control valve, solenoid, wiring, or appurtenance to correct operational deficiencies.
4. Replace, adjust, or move water emission devices to correct operation or coverage deficiencies.
5. Replace defective pipe, fitting, joint, valve, sprinkler, or appurtenance to correct leakage problems.
6. Cement or caulking to seal leaks is prohibited.
7. Repeat test(s) until each lateral passes all tests.
8. The Owners' Representative will measure and record static and dynamic pressure at the point of connection and in the system mainline at various locations.
9. The Owner's Representative will measure and record dynamic pressure at various sprinklers and water emission devices.

1.07 CONSTRUCTION REVIEW

- A. The purpose of on-site reviews by the Owners' Representative is to periodically observe the work in progress and the Contractor's interpretation of the construction documents and to address questions with regards to the installation.
 1. Scheduled reviews such as those for irrigation system layout or testing should be scheduled with the Owners' Representative as required by these specifications.

2. Impromptu reviews may occur at any time during the project.
3. Final review will occur at the completion of the irrigation system and Record Drawing (As-Built) submittal.

1.08 GUARANTEE/WARRANTY AND REPLACEMENT

- A. The purpose of this guarantee/warranty is to ensure that the Owner receives irrigation materials of prime quality, installed and maintained in a thorough and careful manner.
 1. For a period of one year from commencement of the formal maintenance period, guarantee/warranty irrigation materials, equipment, and workmanship against defects. Fill and repair depressions. Restore landscape or structural features damaged by the settlement of irrigation trenches or excavations. Repair damage to the premises caused by a defective item. Make repairs within seven (7) days of notification from the Owners' Representative.
 2. Costs for all guarantee/warranty work shall be entirely paid for by the Contractor.
 3. Contract documents govern replacements identically as with new work. Make replacements at no additional cost to the contract price.
 4. Guarantee/warranty applies to originally installed materials and equipment and replacements made during the guarantee/warranty period.

PART 2 - MATERIALS

2.01 QUALITY

- A. Use materials that are new and without flaws or defects of any type and are the best of their class and kind.

2.02 SUBSTITUTIONS

- A. Pipe sizes referenced in the Construction Documents are minimum sizes and may be increased at the option of the Contractor. Substitutions in pressure class of pipe shall be approved by the Irrigation Designer.

2.03 SLEEVING

- A. Install separate sleeve beneath paved areas to route each run of irrigation pipe or wiring bundle.
- B. Sleeving material beneath pedestrian pavements shall be Class 200 PVC or other bell end pipe with solvent welded joints.
- C. Sleeving beneath drives and streets shall be Class 200 PVC or other bell end pipe with solvent welded joints.
- D. Sleeving diameter: As indicated on the drawings and installation details or equal to twice the nominal diameter of the pipe or wiring bundle being sleeved.
 1. Furnish and install size sleeves for wiring bundles per the current NEC Conduit Fill calculations and charts.

2.04 PIPE AND FITTINGS

- A. Mainline Pipe and Fittings:
 1. Use rigid, unplasticized polyvinyl chloride (PVC) round pipe, National Sanitation

Foundation (NSF) approved, extruded from material meeting the requirements of Cell Classification 12454 as defined in ASTM Standard D1784, with an integral belled end.

2. Use Class 200, SDR-21, rated at 200 PSI, conforming to the dimensions and tolerances established by ASTM Standard D2241 and ASTM Standard D2672. Use PVC pipe rated at higher pressures than Class 200 in the case of small nominal diameters which are not manufactured in Class 200.
 - a. Use solvent weld pipe for mainline pipe with a nominal diameter less than 3-inches or where a pipe connection occurs in a sleeve. Use Schedule 40/80, Type 1, Cell Classification 12454, PVC solvent weld fittings conforming to ASTM Standard D1784 and ASTM Standard D2466 (Schedule 40)/D2467 (Schedule 80). All belled end pipe shall have tapered sockets to create an interference type fit, which meet or exceed the dimensional requirements and minimum socket length for pressure type sockets as defined by ASTM Standard 2672. Use primer specifically approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564.
3. Contractor shall run a #14-AWG, direct bury, UL listed wire by Paige Wire along the entire mainline length. Wire shall be continuous with wire splices only placed within valve boxes and labeled on the record drawing. No wires are to be exposed. Use purple jacketed wire for mainline runs. Tape the tracer wire to the pipe at 15-foot intervals. Label tracer wire runs in each valve box.

B. Lateral Pipe and Fittings:

1. Use rigid, unplasticized polyvinyl chloride (PVC) round pipe, National Sanitation Foundation (NSF) approved, extruded from material meeting the requirements of Cell Classification 12454 as defined in ASTM Standard D1784, with an integral belled end.
2. Use Class 200, SDR-21, rated at 200 PSI, conforming to the dimensions and tolerances established by ASTM Standard D2241. Use PVC pipe rated at higher pressures than Class 200 in the case of small nominal diameters that are not manufactured in Class 200. All belled end pipe shall have tapered sockets to create an interference type fit, which meet or exceed the dimensional requirements and minimum socket length for pressure type sockets as defined by ASTM Standard 2672.
 - a. Use Schedule 40/80, Type 1, Cell Classification 12454, PVC solvent weld fittings conforming to ASTM Standard D1784 and ASTM Standard D2466 (Schedule 40)/D2467 (Schedule 80).
 - b. Use primer approved by the pipe manufacturer. Solvent cement to conform to ASTM Standard D2564, of a type approved by the pipe manufacturer.
 - 1) Solvent welded pipe shall not be installed when the outside temperature drops below forty-five (45) degrees Fahrenheit.
 - c. Flexible high-density polyethylene (HDPE) pipe is an alternate to rigid PVC pipe for lateral piping only.
 - 1) Use SDR-11.5, PE23, rated at 100 PSI that is National Sanitation Foundation (NSF) approved, conforming to ASTM Standard D2239.
 - 2) Use Type 1, cell classification 12454PVC as defined in ASTM Standard D1784 insert fittings conforming to ASTM Standard D2609 designed for use with flexible polyethylene (PE) pipe. Use stainless steel pinch clamps or worm gear clamps (including stainless steel screw) to join pipe and fittings.

3. Low Density Polyethylene Hose:
 - a. Use pipe specifically intended for use as a flexible swing joint.
 - 1) Inside diameter: 0.490+0.010 inch
 - 2) Wall thickness: 0.100+0.010 inch
 - 3) Color: Black
 - 4) Pressure Rating: 80 PSI
 - b. Use spiral barb fittings supplied by the same manufacturer as the hose.
4. Assemblies calling for threaded pipe connections shall utilize PVC Schedule 80 nipples and PVC Schedule 80 threaded fittings.
5. Joint sealant:
 - a. Use only Teflon-type tape pipe joint sealant on plastic threads. Use nonhardening, nontoxic pipe joint sealant formulated for use on water-carrying pipes on metal threaded connections.
6. Marking Tape:
 - a. Mainline Pipe - Christy underground I.D. tape TA.DT.6.P.NPW.

2.05 MAINLINE COMPONENTS

- A. Main System Shutoff Valve: As per local practice and in compliance with local code.
- B. Winterization Assembly: As per local practice and in compliance with local code.
- C. Backflow Prevention Assembly: As presented in the installation details and in compliance with local code.
- D. Master Valve Assembly: As presented in the installation details.
- E. Flow Sensor Assembly: As presented in the installation details.
- F. Isolation Gate Valve Assembly: As presented in the installation details. Install a separate valve box over a 3-inch depth of 3/4-inch gravel for each assembly.
- G. Quick Coupling Valve Assembly: Double swing joint arrangement as presented in the installation details. Install at a height where key can be inserted, turned and valve pressurized without removing threaded handle.
- H. Combination Pressure Regulator/Wye-Strainer Assembly: As presented in the installation details. Install a separate valve box over a 3-inch depth of 3/4-inch gravel for each assembly.
- I. Pressure Regulator Assembly: As presented in the installation details. Install a separate valve box over a 3-inch depth of 3/4-inch gravel for each assembly.
- J. Wye-Strainer Assembly: As presented in the installation details. Install a separate valve box over a 3-inch depth of 3/4-inch gravel for each assembly.
- K. Manual Drain Valve Assembly: As presented in the installation details. Install a separate sump consisting of a minimum of nine cubic feet of 3/4-inch gravel for each drain valve.
- L. Air/Vacuum Relief Valve Assembly: As presented in the installation details.

2.06 SPRINKLER IRRIGATION COMPONENTS

- A. Remote Control Valve (RCV) Assembly for Sprinkler and Bubbler Laterals:
1. As presented in the installation details. Use wire connectors and waterproofing sealant to join control wires to solenoid valves. Use standard identifications tags marked with controller name and station number. Install a separate valve box over a 3-inch depth of washed pea gravel for each assembly. Use 8-ounce minimum weight non-woven geotextile fabric underneath pea gravel and box assembly to prevent dirt and debris intrusion. Adjust valve flow control per manufacturer's recommendations prior to use.
 - a. Install decoder compatible with irrigation controller on each valve for communication on 2-wire control system.
 2. Sprinkler Assembly: As presented in the drawings and installation details.

2.07 CONTROL SYSTEMS COMPONENTS

- A. Controller – Existing Bison Exhibit controller to be obtained from zoo staff and installed in new cheetah exhibit structure. Controller to be connected to zoo central control system and be programmed to utilize flow data from the central control system.
- B. Control Wire:
1. Use American Wire Gauge (AWG) No.12/14 solid copper conforming to ASTM B-3 or ASTM B-8. Type UF or PE cable, UL approved for direct underground burial from the controller unit to each remote-control valve. Use American Wire Gauge (AWG) No.12 wire for common wire.
 - a. Type PE Cable:
 - 1) Minimum temperature rating of 60° C and 600 volts.
 - 2) Minimum insulation thickness of 0.060".
 - 3) Sunlight resistant, testing at 300 hours of carbon-arc or xenon-arc exposure.
 - 4) Cold Bend Test: Insulation shall not show any cracks when sample is bent around a 3X mandrel after being subjected to minus 25° C for four (4) hours.
 - 5) Insulation shall not absorb more than 25mg mass of water per square inch.
 - b. Wire Color for Conventional Wire Controllers:

1) Common	White
2) Turf	Green
3) Native Seed	Orange
4) Drip to Shrubs	Yellow
5) Drip to Trees	Red
6) Drip to Planters/Pots/Perennials	Blue
7) Spare Wires	Purple
8) Tracer Wire	Pink
- C. Splices: Use wire connectors with waterproof sealant. Wire connector to be of UV radiation resist plastic construction consisting of two pieces, one piece which snap locks into the other. Connector shall be pre-filled with non-hardening silicone gel. Utilize twist style wire connector

provided with assembly to connect wires.

1. Wire connectors to meet requirements of UL Standard 486D
 2. Utilize DBR/Y-600 Black Splices
 3. Encase wiring not located near PVC irrigation pipe in PVC Schedule 80 electrical conduit. Utilize long sweep elbows for changes of direction.
- D. Warning tape: Detectable Warning Tape reading “Caution: Buried Electrical Line Below” shall be inert plastic film highly resistant to alkalis, acids, or other destructive chemical components likely to be encountered in soils. Tape shall be six inches wide, colored red.
- E. Grounding
1. All controllers and decoders are to be grounded as indicated on the drawings. Minimum grounding per details and per the ASIC detail for controller grounding.
 2. Grounding shall be a rod and plate arrangement for the controller.
 3. Grounding Rod
 - a. 5/8-inch diameter, UL listed, copper-clad ground rod, 8-feet in length, with a 10-AWG factory welded insulated conductor, 15-feet in length.
 - b. Manufacturer shall be Paige Wire, model number 182000IC10 or approved equal.
 - c. Clamps, wire nuts, and / or CADWELD “One-Shot” connectors are not approved for use.
 - d. Install rod per manufacturers guidelines as to not damage the rod or welded conductor.
 - e. Ground rods shall be placed in their own ten-inch round valve box.
 4. Grounding Plate
 - a. 4-inch by 36-inch copper ground plate with a 10-AWG welded insulated conductor, 10-feet in length.
 - b. Manufacturer shall be Paige Wire, model number 182201IC or approved equal.
 - c. Provide 50-pounds of ground enhancement material (GEM) / earth contact backfill on the top and the bottom of each plate, for a total of 100-pounds per plate.
 - d. Manufacture shall be Loresco, Paige Electric model number 1820058 or 1820059 based on site soil conditions or approved equal.
 5. All wire connections between the ground rod and ground plate leads to the surge suppression device shall be made via a Paige Wire re-enterable terminal connector, model number 270RC3 or approved equal.
 6. The Contractor will be responsible to provide earth ground of two-wire ohm reading of not more than ten-ohms or approved in writing from the manufacture or within manufacture’s acceptable range.
 7. The supplying distributor shall check all ohm readings with a ground resistance tester (commonly referred to as a “Megger”) and provide documentation, signed by the distributor, that all readings are under ten-ohms. The Contractor will be responsible for making adjustments to the grounding system to achieve this reading at no additional cost to the Owner.

2.08 OTHER COMPONENTS

- A. Tools and Spare Parts: Provide operating keys, servicing tools, test equipment, other items and spare parts indicated in the General Notes of the drawings.
 - 1. Additionally, provide the following:
 - 2. Two operating keys for each type and size of manually operated valve.
 - 3. Two keys for each type and size of quick coupler.
 - 4. Two of each servicing wrench or tool needed for complete access, adjustment, installation of nozzles and repair of all spray, rotary and rotor type sprinklers.
 - 5. Two 3" diameter pressure gauges and associated fittings to measure system pressure and pressure at spray, rotary and rotor type sprinklers and remote-control valves. Pressure gauge shall have a range of 0-160 PSI.
 - 6. Two sets of keys for each controller, enclosure or equipment that requires keyed access.
 - a. If required, keys shall be keyed to match other locks that the Owner possess.
 - 7. All instruction manuals, repair manuals, operating manuals and original paper work related to the products that were installed during construction of the irrigation system.
- B. Owner Stock: Include the following for owner stock for future replacements.
 - 1. Five (5) of each type of spray and rotary sprinkler body.
 - 2. Five (5) of each type of rotor body.
 - 3. Ten (10) of each type, radius, arc, and nozzle of spray and rotary sprinkler.
 - 4. Ten (10) of each type and size of rotor nozzle.
 - 5. Ten (10) sets of waterproof connectors.

PART 3 - EXECUTION**3.01 INSPECTION AND REVIEWS**

- A. Site Inspections:
 - 1. Verify site conditions and note irregularities affecting work of this section. Report irregularities to the Owners' Representative prior to beginning work.
 - 2. Beginning work of this section implies acceptance of all existing conditions.
 - 3. Contractor will be held responsible for coordination between landscape and irrigation system installation.
 - 4. Landscape material locations shown on the Landscape Plan shall take precedence over the irrigation system equipment locations. If irrigation equipment is installed in conflict with the landscape material locations shown on the Landscape Plan, the Contractor will be required to relocate the irrigation equipment, as necessary, at Contractor's expense.
- B. Utility Location (Call Before You Dig)
 - 1. Arrange for and coordinate with local authorities the location of all underground utilities.
 - 2. Repair any underground utilities damaged during construction. Make repairs at no additional cost to the contract price.

- C. Irrigation System Layout Review: Irrigation system layout review will occur after the staking has been completed. Notify the Owners' Representative three business days in advance of review. Modifications will be identified by the Owners' Representative at this review.

3.02 LAYOUT OF WORK

- A. Stake out the irrigation system. Adjust system layout from plans to conform to final approved landscape design. Items staked shall include: Sprinklers, pipe, control valves, manual drains, controller, and isolation valves, grounding locations and sleeving.
- B. Install all mainline pipe and mainline components inside of project property lines.

3.03 EXCAVATION, TRENCHING AND BACKFILLING

- A. Excavate to permit the pipes to be laid at the intended elevations and to permit work space for installing connections and fittings.
- B. Minimum cover (distance from top of pipe or control wire to finish grade):
 - 1. 24-inch over mainline pipe and over electrical conduit.
 - 2. 26-inch over control wire.
 - 3. 18-inch over lateral pipe to sprinklers.
 - 4. 8-inch over drip lateral pipe in turf or paved areas downstream of drip system zone control valves.
 - 5. 3-inch minimum mulch cover over drip lateral pipe in planting beds downstream of drip system zone control valves. PVC UV radiation resistant lateral pipe shall be installed directly on the soil surface under landscape fabric.
- C. Backfill only after lines have been reviewed and passed hydrostatic tests and accepted by the Owner.
 - 1. Excavated material is generally satisfactory for backfill. Backfill shall be free from rubbish, vegetable matter, frozen materials, and stones larger than 1/2-inch in maximum dimension. Remove material not suitable for backfill. Backfill placed next to pipe shall be free of sharp objects which may damage the pipe. All soil shall be screened and pass through a square opening 1/2" x 1/2".
 - 2. Backfill un-sleeved pipe and sleeves in either of the following manners:
 - a. Backfill and puddle the lower half of the trench. Allow to dry 24 hours. Backfill the remainder of the trench in 6-inch layers. Compact to density of surrounding soil.
 - b. Backfill the trench by depositing the backfill material equally on both sides of the pipe in 6-inch layers and compacting to the density of surrounding soil.
 - 3. Enclose pipe and wiring beneath roadways, walks, curbs, etc. in sleeves. Minimum compaction of backfill for sleeves shall be 95% Standard Proctor Density, ASTM D698-78. Conduct one compaction test for each sleeved crossing less than 50 feet long. Conduct two compaction tests for each sleeved crossing greater than 50 feet long. Costs for such testing and any necessary retesting shall be paid for by the Contractor. Use of water for compaction around sleeves, puddling, will not be permitted.
 - 4. Dress backfilled areas to original grade
 - 5. Where utilities conflict with irrigation trenching and pipe work, contact the Owners' Representative for trench depth adjustments.

3.04 SLEEVING AND BORING

- A. Install sleeving at a depth which permits the encased pipe or wiring to remain at the specified burial depth.
- B. Extend sleeve ends six inches beyond the edge of the paved surface. Cover pipe ends and mark with stakes. Mark concrete with a chiseled "X" at sleeve end locations.
- C. Bore for sleeves under obstructions which cannot be removed. Employ equipment and methods designed for horizontal boring.

3.05 ASSEMBLING PIPE AND FITTINGS

- A. General:
 - 1. Keep pipe free from dirt and pipe scale. Cut pipe ends square and deburr. Clean pipe ends.
 - 2. Keep ends of assembled pipe capped to prevent dirt and debris intrusion. Remove caps only when necessary to continue assembly.
- B. Mainline Pipe and Fittings:
 - 1. Use only strap-type friction wrenches for threaded plastic pipe. Tighten threaded plastic pipe per pipe and fitting manufacturers recommendations.
 - 2. PVC Solvent Weld Pipe:
 - a. Use primer and solvent cement. Join pipe in a manner recommended by the manufacturer and in accordance with accepted industry practices.
 - b. Cure for 30 minutes before handling and 24 hours before allowing water in pipe.
 - c. Snake pipe from side to side within the trench.
 - 3. Fittings: The use of cross and wye type fittings is not permitted.
- C. Lateral Pipe and Fittings:
 - 1. Use only strap-type friction wrenches for threaded plastic pipe. Tighten threaded plastic pipe per pipe and fitting manufacturers recommendations.
 - 2. PVC Solvent Weld Pipe:
 - a. Use primer and solvent cement. Join pipe in the manner recommended by the manufacturer and in accordance with accepted industry practices.
 - b. Cure for 30 minutes before handling and 24 hours before allowing water in the pipe.
 - c. Snake pipe from side to side within the trench.
 - 3. Polyethylene (PE) Pipe:
 - a. Join pipe in the manner recommended by manufacturer and in accordance with accepted industry practices.
 - b. Snake pipe from side to side within the trench.

3.06 INSTALLATION OF MAINLINE COMPONENTS

- A. Main System Shut Off Valve: Install where indicated on the drawings.
- B. Winterization Assembly: Install where indicated on the drawings.
- C. Backflow Prevention Assembly: Install where indicated on the drawings. Install assembly so

that its elevation, orientation, access, and drainage conform to the manufacturer's recommendations and applicable health codes.

- D. Master Valve Assembly: Install where indicated on the drawings.
- E. Flow Sensor Assembly: Install where indicated on the drawings.
- F. Isolation Gate Valve Assembly:
 - 1. Install where indicated on the drawings.
 - 2. Locate at least 12-inches from and align with adjacent walls or edges of paved areas.
- G. Quick Coupling Valve Assembly: Install where indicated on the drawings.
- H. Combination Pressure Regulator/Wye-Strainer Assembly: Install where indicated on the drawings.

3.07 INSTALLATION OF SPRINKLER IRRIGATION COMPONENTS

- A. Remote Control Valve (RCV) Assembly for Sprinkler Laterals:
 - 1. Flush mainline before installation of RCV assembly.
 - 2. Install where indicated on the drawings. Wire connectors and waterproof sealant shall be used to connect control wires to remote control valve wires. Install connectors and sealant per the manufacturer's recommendations.
 - 3. Install only one RCV to a valve box. Locate valve box at least 12-inches from and align with nearby walls or edges of paved areas. Group RCV assemblies together where practical. Arrange grouped valve boxes in rectangular patterns. Allow at least 12-inches between valve boxes.
 - 4. Adjust RCV to regulate the downstream operating pressure.
 - 5. Attach ID tag with controller station number to control wiring.
- B. Sprinkler Assembly:
 - 1. Flush lateral pipe before installing sprinkler assembly.
 - 2. Install per the installation details at locations shown on the drawings.
 - 3. Locate rotary sprinklers 6-inches from adjacent walls, fences, or edges of paved areas.
 - 4. Locate spray sprinklers 3-inches from adjacent walls, fences, or edges of paved areas.
 - 5. Set sprinklers perpendicular to the finish grade.
 - 6. Supply appropriate nozzle or adjust arc of coverage of each sprinkler for best performance.
 - 7. Adjust the radius of throw of each sprinkler for best performance.

3.08 INSTALLATION OF CONTROL SYSTEM COMPONENTS

- A. Irrigation Controller Unit:
 - 1. The location of the controller unit as depicted on the drawings is approximate; the Owners' Representative will determine the exact site location upon commencement of contract during sprinkler layout review.
 - 2. Lightning protection: Ground rods are to have a minimum diameter of 3/4" and a minimum length of 10 feet. These are to be driven into the ground in a vertical position or an oblique

angle not to exceed 15 degrees at location 10 feet from the electronic equipment, the ground plate, or the wires and cables connected to said equipment, as shown in the irrigation details. The rod is to be stamped with the UL logo. A 6 AWG solid bare copper wire (no more than 12 feet long) shall be connected to the ground rod by the installer using a Cadweld GR1161G" One-Shot" welding kit. This wire shall be connected to the electronic equipment ground lug as shown in the detail above.

3. Lightning protection: Provide on all remote-control valve wiring as recommended by the manufacturer. Provide other components such as ground rod, grounding wire, etc., to manufacturer's recommendations.
 4. Install primary surge protection arrestors on incoming power lines.
 5. Install one valve output surge protection arrestor on each control wire and one for the common wire.
 6. Attach wire markers to the ends of control wires inside the controller unit housing. Label wires with the identification number (see drawings) of the remote-control valve to which the control wire is connected.
 7. Connect control wires to the corresponding controller terminal.
- B. Instrumentation:
1. Install sensors per the installation details and manufacturer's recommendations. Install at locations shown on the drawings.
 2. Install electrical connections between irrigation controller and sensors per manufacturer's recommendations.
- C. Control Wire:
1. Bundle control wires where two or more are in the same trench. Bundle with pipe wrapping tape spaced at 10-foot intervals.
 2. Decoder Systems: Where 2-wire decoder cable is used, install decoder cable fuse devices for wire-path trouble-shooting at each intersection where the cable splits in different directions, and in long cable runs between groups of multiple decoders. Install device per manufacturer's recommendations.
 3. Provide a 24-inch excess length of wire in an 8-inch diameter loop at each 90-degree change of direction, at both ends of sleeves, and at 100-foot intervals along continuous runs of wiring. Make wiring loop by turning control wire 5 turns around 1-inch pipe. Coil 24-inch length of wire within each remote-control valve box.
 4. Install common ground wire and one control wire for each remote-control valve. Multiple valves on a single control wire are not permitted.
 5. If a control wire must be spliced, make splice with wire connectors and waterproof sealant, installed per the manufacturer's instructions. Locate splice in a valve box which contains an irrigation valve assembly, or in a separate 6-inch round valve box. Use same procedure for connection to valves as for in-line splices.
 6. Unless noted on plans, install wire parallel with and under PVC mainline pipe. If wire is installed adjacent to section of metal pipe, separate wire from pipe minimum of 6-inches and install wire in PVC conduit.
 7. Encase wire not installed with PVC mainline pipe in electrical conduit.

- D. Warning tape: Detectable Warning Tape shall be installed approximately 6 inches above mainline pipe where required or where specified.

3.09 INSTALLATION OF OTHER COMPONENTS

- A. Tools and Spare Parts:
 - 1. Prior to the Pre-Maintenance Review, supply to the Owner operating keys, servicing tools, test equipment, and any other items indicated on the drawings.
 - 2. Prior to Final Review, supply to the Owner the spare parts indicated in the General Notes on the drawings.
- B. Other Materials: Install other materials or equipment shown on the drawings or installation details to be part of the irrigation system, even though such items may not have been referenced in these specifications.

3.10 PROJECT RECORD (AS-BUILT) DRAWINGS

- A. Maintain on-site and separate from documents used for construction, one complete set of contract documents as Project Documents. Keep documents current. Do not permanently cover work until as-built information is recorded.
- B. Record pipe and wiring network alterations. Record work which is installed differently than shown on the construction drawings. Record accurate reference dimensions, measured from at least two permanent reference points, of each irrigation system valve, each backflow prevention device, each controller or control unit, each sleeve end, each stub-out for future pipe or wiring connections, and other irrigation components enclosed within a valve box.
- C. Prior to Final Review, purchase from the Owners' Representative a reproducible mylar copy of the drawings. Using technical drafting pen, duplicate information contained on the project drawings maintained on site. Label each sheet "Record Drawing". Completion of the Record Drawings will be a prerequisite for the Final Review.

3.11 MAINTENANCE

- A. Upon completion of Final Review, maintain irrigation system for a duration of 30 calendar days. Make periodic examinations and adjustments to irrigation system components to achieve the most desirable application of water.
- B. Following completion of the Contractor's maintenance period, the Owner will be responsible for maintaining the system in working order during the remainder of the guarantee/warranty period, for performing necessary minor maintenance, for trimming around sprinklers, for protecting against vandalism, and for preventing damage during the landscape maintenance operation.

3.12 CLEAN-UP

- A. Upon completion of work, remove from the site all machinery, tools, excess materials, and rubbish.

END OF SECTION 32 8400

SECTION 32 9115 - PLANTING SOILS

PART 1 - GENERAL

1.1 GENERAL REFERENCE

- A. The work of this Section is integral with the whole of the Contract Documents and is not intended to be interpreted outside that context.
- B. This Section includes planting soils for use in landscape contexts both within the habitat of the exhibit and restoration and landscape improvements outside of the exhibit in public areas.
 - 1. Habitat planting soils consist of two layers of horticultural soils. 12" of Planting Soil over 24" or less of Horticultural Subsoil, and bioinfiltration soils
 - 2. The horticultural soils within the habitat will be armored with filter fabric and stone mulch of varying thickness and compositions of sand, crushed stone and boulders to protect the placed soils from erosion, provide for native talus stone habitat and to minimize establishment of native and non-native weed populations. Habitat Soils include the following:
 - a. Planting Bed Soil
 - b. Horticultural Subsoil
 - c. Bioretention Planting Soil
 - d. Bioretention Subsoil
 - 3. The horticultural soils outside of the habitat, in front of the exhibit building entrance, along Olmstead Path and for other public area landscape restoration areas, will consist of imported planting soils, as well as existing landscape soil restoration within the rootzone of existing trees. Non-Habitat Soils include the following:
 - a. Planting Bed Soil
 - b. Sand based Structural Soil
 - c. Horticultural Subsoil
 - d. Soil Restoration amendment

1.2 SCOPE OF WORK

- A. This Section specifies administrative and procedural requirements for planting soil including, but not limited, to the following:
 - 1. Imported planting soil components material acquisition.
 - 2. Testing of existing topsoil decompaction and soil amendment as required.
 - 3. Testing and analysis for specification conformance.
 - 4. Inspection and testing of subgrade for preparation of subgrade.
 - 5. Preparation of planting soil blends and testing for conformance and quality control.
 - 6. Preparation of Mock-up of subgrade preparation.
 - 7. Mock-up, installation and placement of planting soils, and stone mulch.
 - 8. Compaction of planting soils.
 - 9. Final in-place testing of planting soils.

10. Coordination with other contractors.
11. Clean-up.
12. Project-close out and Warranty.

B. References to other Sections are given that may duplicate provisions in this Section.

1.3 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to all Sections. The Contract Documents are complementary, and what is required by one shall be as binding as if required by all.

1.4 RELATED WORK UNDER OTHER SECTIONS

- A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:
1. Section 312000 - Earth Moving
 2. Section 328400 - Irrigation System
 3. Section 329300 – Planting and Fine Grading

1.5 DEFINITIONS

- A. Definitions/References:
1. Finish Grade: Elevation of finished surface of planting soil after settlement.
 2. Imported Planting Soils for Soil Profiles: Soil produced from off-site sources by homogeneously blending mineral soils or sand with mature and stable organic compost to produce specified planting soil blends.
 3. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soils.
 4. Contractor: The Contractor performing the work specified herein.
 5. ASA: American Society of Agronomy
 6. ASTM: American Society of Testing Materials.
 7. AOAC: Association of Official Agricultural Chemists.
 8. Soil Scientist: The project Soil Scientist shall be Pine and Swallow Environmental, 867 Boston Rd., Groton, MA 01450, 978-448-9511, www.pineandswallow.com
 9. Drainage Layer/Drainage Blanket: A layer of specified sand to facilitate drainage and control of groundwater below planting soils.
 10. Imported Planting Soils: Planting Soils are composed of a blend of three base components: base loam, organic material and sand. The quality of the blend depends on the quality of the original components. Locate and obtain approval of sources for base loam, organic material and sand that meet the Specification requirements. Contractor is then responsible for mixing the components. Approximate mixing ratios are provided, but may require adjustment, depending on the final materials and with the approval of the Architect or their representative, in order to meet Specification requirements for each blend.

11. Habitat: Non-public areas inside of the enclosure for the Arabian Leopard Exhibit. Special soil requirements for habitat soils are specified herein.
12. Talus/Talus Stone: Geologically, talus describes accumulations of angular large, loose boulders at the base of a cliff. For the Arabian Leopard habitat, talus is a blend of large stones to sand size material that will armor the horticultural soils from erosion and weed growth. The horticultural soils will be covered with a variable composition and thickness of quarried stone, crushed rock and tailings or stone dust to create the desired habitat and landscape performance requirements.
13. Final Acceptance: Final Acceptance shall be the day on which the project is 100% complete and accepted by the Landscape Architect and Owner, including "Punch List" items. Maintenance and Warranty work shall commence at Final Acceptance.

B. Testing/Testing Agency

1. Section 312000 – Earth Moving
2. Refer to this Section, Part 1.

1.6 QUALITY ASSURANCE

- A. Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture that has, and must be able to demonstrate that they have, the experience and capability to conduct the testing indicated and that they specialize in types of tests to be performed.
1. Employ at Contractor's expense a qualified independent testing and inspection laboratory acceptable to the Landscape Architect and Owner to perform all compaction, moisture and infiltration tests and certifications as specified herein including both laboratory and field-testing. Tests shall be made in strict compliance with the standards of the AOAC, ASTM, or as described herein. Field testing results shall be emailed within 2 days to the Landscape Architect and Soil Scientist.
 - a. It is the responsibility of Landscape Contractor in conjunction with the Soil Supplier to submit material for the soil and compost tests.
- B. Contractor Experience
1. Candidate Contractor shall submit written documentation of at least five years of contracting and landscape construction experience completing projects of similar scope, complexity and value.
 2. Candidate Contractor shall submit written documentation of at least five projects in which engineered blended horticultural soil was used.
- C. Critical Path Processing - Soils Testing Report Submittals:
1. Critical Path Processing: The Contractor shall be responsible for recognizing that these critical project materials warrant timely attention, that the procurement process and testing protocols to achieve approved materials shall be considered a long lead time item. Under no circumstance shall failure to comply with all specification requirements be a reason for substitution of unacceptable material(s).
- D. Construction Observations
1. The Contractor shall not place any Soil Blend or Sand on Subgrade prior to inspection and approval by the Landscape Architect or Owner's Representative for compliance with

grading and compaction and infiltration specifications. At locations selected by the Landscape Architect, the Contractor shall submit spot grades of the subgrade to the Landscape Architect. The Contractor shall request inspection seven days before proceeding.

2. The Contractor shall not place any horticultural soils prior to inspection and approval by the Landscape Architect for compliance with subgrade depth, grading and compaction specifications. The Contractor shall request inspection seven days before proceeding.

E. Regulatory Requirements

1. Comply with laws, regulations, and quarantines for agricultural and horticultural products.
2. Contractor shall submit certification that all soil blend components and all soil blends meet all environmental standards of the District of Columbia. Refer to the project's Environmental Consultant. Testing of imported soils for oil and hazardous material (OHM) is not included in this Section. Testing and compliance of horticultural soils for OHM shall be at the direction of the Soil Management Plan, Environmental Consultant or other entity designated by the Owner.

F. Planting Soil Testing Protocol

1. The Appendix summarizes the process of planting soil testing, submittal, and evaluation.

1.7 TESTING, SUBMITTALS AND MOCK-UPS

- A. Certificates: Provide certificates required by authorities having jurisdiction for any composted materials. Contractor shall submit certification that all soil blend components and all soil blends meet all environmental standards of the Commonwealth of Massachusetts.

B. Testing for Subgrade, Planting Soil Components, Existing Stripped Topsoil, and Planting Soil Mixes: Testing is required at the following intervals: (if required)

1. Testing of individual components (Base Loam, Sand, and Compost) for planting soil mixes shall be carried out by the Soils Testing Laboratory. Recommendations for amending and/or correcting the soil mix will be provided to the Contractor by the Soil Supplier.
2. Failure of any material by testing and/or amendment procedure to meet Specification requirements shall require the Contractor to seek another source for the failed material and the initiation of all testing procedures for the new replacement material shall immediately take place.
3. After test results for components have been accepted, create sample mixes of each planting soil mix and perform tests described in Section 329115, Part 1.
 - a. Planting Soil Mixes shall be compliant to Section 329115, Part 2.
4. After the test results for planting soil mixes have been accepted, and during the production of planting soils, test every 200 cubic yards of every Soil Mix blended for: organic matter content, gradation, and pH. Before shipping of any Planting Soil Mix, the Contractor shall confirm that the Soil Scientist has accepted the mix. Testing applies to all soil layers of the planting profile. After three consecutive compliant tests, the Contractor may increase the interval of testing to 500 cubic yards. Approval is required before shipment.
5. Laboratory test reports for components and blend batch stockpiles, and blend production stockpiles shall be no older than three months from date of submittal. Compost maturity

- and stability as per Part 2 shall be tested every month after initial acceptance and during and until final blend production.
6. Testing of Subgrade: Prior to placement of the planting soil profile, test the subgrade as described in this Section 329115, Part 3. Coordinate the testing of the subgrade with the Sitework Contractor before the planting soil profile is placed.
 7. Testing of existing stripped topsoil: organic matter content, gradation, and pH (if required).
 8. In-place tests: Compaction tests of each type of material placed in accordance this section. Infiltration tests shall be in accordance with this Section.
- C. Test Reports: Submit certified reports for tests as described in this Section.
1. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System using sieve size nos. 10, 18, 35, 60, 140 and 270. Percent clay (0.002 mm) shall be reported separately in addition to silt (via hydrometer method: ASTM D6913 and ASTM D7928).
 2. The silt and clay content shall be determined by a Hydrometer Test of soil passing the #270 sieve.
 3. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium, Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, organic matter content, acidity (pH) and buffer pH.
 4. Tests shall be conducted in accordance with Recommended Soil Testing Procedures for the Northeastern United States, 2nd Edition, Northeastern Regional Publication No. 493. Tests include the following:
 - a. Test for soil Organic Matter by loss of weight on ignition.
 - b. Test for soil CEC by exchangeable acidity method.
 - c. Test for soil Soluble Salts shall be by the 1:2 (v:v) soil:water Extract Method.
 - d. Test for Buffer pH by the SMP method.
 - e. Tests for pH shall be conducted on a 1:1 soil to distilled water ratio.
 5. Certified reports on analyses from producers of composted organic materials shall be required and new test reports shall be submitted when sources or material are changed. Analyses shall include all tests for criteria specified in Part 2.
 6. Saturated hydraulic Conductivity: Test procedure ASTM D2434.
 - a. Hydraulic Conductivity tests shall be taken of samples during QA/QC testing at the Soil Supplier's facility. Samples from each stockpile for each soil blend shall be tested.
 7. Testing Agencies: The following firms are acceptable testing agencies for the various components.
 - a. Leaf Yard Waste Compost Stability Test: Woods End Laboratories, 150 Whitten Road, Augusta, ME, 04330, tel: 201.293.2457, or approved equal
 - b. Mechanical Gradation, Chemical Analysis and Organic Matter Content, All Soil Components and Planting Soil Mixes: University of Massachusetts, 203 Paige Laboratory, 161 Holdsworth Way, Amherst, MA 01003, <http://soiltest.umass.edu>, tel: 413.545.2311, or approved equal.
 - c. All other tests except those listed above: Certified Testing laboratory (CTL), 155 US Route 130, Bordentown, NJ 08505, tel: 609.298.3255 www.certifiedtestinglabs.com or approved equal.
 8. Laboratory Density Testing Submittal: ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort

- a. Standard Proctor density tests shall be performed on samples collected at the Soil Supplier's facility, to obtain the optimum moisture content and maximum dry density values.
- 9. Test Report Timeliness
 - a. All submitted test reports must be from recent analyses, less than 90 days old, and represent materials that are available for delivery to the site.
 - b. Base component materials should be blended into soil blends within 90 days of test reports. Soil blends should be delivered to the project site or be reserved for project use at designated areas within 90 days of test reports for each soil blend. Soil blends may be mixed, approved by the Design team, and stockpiled in advance. If stockpiling occurs, the Construction and Design teams should be notified, and the storage period shall be up to 360 days. In the event of long-term storage beyond 90 days, new samples of each stored stockpile shall be tested for gradation, organic matter content and pH and results submitted for approval.
 - c. Pre-blended and accepted stockpiles should be stored in accordance with Specification Requirements and be labeled and protected.
 - d. If base component test reports expire beyond the 90-day limit while soil blends are being manufactured, the contractor shall submit certification to the design team that the materials are the same materials that were tested and accepted initially and may continue blending using the accepted submittals up to a maximum of 180 days at which time new samples and laboratory tests must be submitted.
- D. In-Place Testing
 - 1. Density Tests: Density of soil and rock in place shall be tested using ASTM D1556 Sand Cone Method or ASTM D6938 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth), and ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. (Standard Proctor).
 - a. In-place density tests shall be carried out at a rate of one test per 1,000 square feet for placed horticultural soils, or at direction of the Landscape Architect or Soil Scientist.
 - b. Density Test results shall be emailed to the Landscape Architect and Soil Scientist within two business days.
 - 2. In-place infiltration tests shall be performed using the Perforated Canister Method or the Turf-Tec IN2-W Infiltrometer utilizing manufacturer's operating instructions.
 - a. Perforated Canister Method
 - 1) Utilize perforated canisters or buckets seven to ten inches in diameter and a minimum of six inches high.
 - 2) A test hole shall be hand dug at the soil horizon to be tested approximately one-inch larger than the diameter of the test canister and approximately six inches deep. The sides of the test hole shall not be smoothed.
 - 3) Place one-half inch of clean coarse sand in the bottom of the hole and place the canister firmly into the hole. The space around the canister shall then be filled with coarse sand. Tamp the coarse sand to firmly fill any void space around the test canister.
 - 4) Fill the canister with water to the soil horizon level and allow to drain until approximately one inch of water remains, or a minimum of 1 hour.
 - 5) Refill the canister to the soil horizon level. After the water level drops approximately one inch, start the test. Record time versus water level as the

water level drops. The percolation rate is the length of time for the water level to drop per inch. The field scientist shall record the rate of percolation for a minimum of two hours or until the water level has dropped a minimum of three inches after the start of measurements.

- 6) The subgrade must be capable of infiltrating water at least one inch per hour (1"/hr) in planted areas and 2"/hour in bioinfiltration soil areas. If subgrade fails to pass water at the minimum rate, the soils shall be re-worked or drainage provisions shall be required.
3. In addition, in-place soil blends may be sampled and tested by the Owner. Tests for gradation and organic matter content shall be compliant with Specifications for that blend.
- E. Prior to ordering the below listed materials, submit representative composite samples to the Landscape Architect, Owner and Soil Scientist for selection and approval. Representative composite samples shall be composed of at least five equal-sized subsamples mixed thoroughly and resampled for submittal. Do not order materials until Landscape Architect's, Owner's Representative's and Soil Scientist's approval has been obtained. Delivered materials shall closely match the approved samples.
1. Base Components
 - a. Leaf and Yard Waste Compost: sample of one gallon.
 - b. Base Loam (for imported soil blends): sample of one gallon.
 - c. Coarse Sand (for imported soil blends, and drainage layer as required): sample of one gallon.
 2. Test Blends
 - a. Planting Bed Soil: sample of one gallon.
 - b. Horticultural Subsoil: sample of one gallon.
 - c. Sand Based Structural Soil: sample of one gallon.
 - d. Bioretention Planting Soil: sample of one gallon.
 - e. Bioretention Subsoil: sample of one gallon.
 3. Production Stockpiles
 - a. Planting Bed Soil: sample of one gallon.
 - b. Horticultural Subsoil: sample of one gallon.
 - c. Sand Based Structural Soil: sample of one gallon.
 - d. Bioretention Planting Soil: sample of one gallon.
 - e. Bioretention Subsoil: sample of one gallon.
 4. Materials
 - a. 3/4" Crushed Stone sample of 1 gallon.
 - b. Sand and Gravel sample of one gallon.
 - c. Letter Certification description of feed stock for Compost.
 - d. Sod Farm Growing Medium: one square foot sample of Sod.
 - e. Stone Mulch Components for Talus slopes
 1. AASHTO #57 Crushed Stone (3/4") (alternate)
 2. AASHTO #6 Crushed Stone (1/2")
 3. AASHTO #7 Crushed Stone (3/8")
 4. AASHTO #8 Crushed Stone (5/16")
 5. AASHTO #9 Crushed Stone (No. 4)
 6. Washed AASHTO #10 Crushed Stone (No. 4)

- F. Sources for Base Loam, Sand, and Compost: Submit information identifying sources for all soil components and the firm responsible for mixing of planting soil mixes.
1. Landscape Architect, Soil Scientist and Owner shall have the right to reject any soil .
 2. Soil mix supplier shall have a minimum of five years-experience at supplying custom planting soil mixes.
 3. Submit supplier name, address, telephone and fax numbers and contact name.
 4. Submit certification that accepted supplier is able to provide sufficient quantities and qualities of materials for the entire project.
 5. Final approval of soil supplier shall be made after on-site review of supplier's facility by the Soil Scientist.
 6. Recommended Soil Suppliers
 - a. Stancils, 499 Mountain Hill Road, Perryville, MD 21903, Contact: Chris Siciliano, chris@stancills.com, 877-536-9572, www. stancills.com.
 - b. WeCare Denali - 7800 Kabik Ct. Woodbine, MD 21797, Contact: David Lundberg, 240-315-5357, www.wecarecompost.com.
 - c. Luck Ecosystems, Stonemule Rd, VA. Contact: John Irby 877-904-5825, https://luckecosystems.com/locations
 - d. Advanced Soil Technologies, 276 Deans Rhode Hall Road, Dayton, NJ 08810, (O) 732.840.1700, Contact: Patrick Schlagenhaft, Patrick@AdvancedSoilTechnologies.com
 - e. The Dirt Company-Northeast, Inc., P.O. Box 156, Jamesburg, NJ., Contact Alan Marolf, (917)524-5054, amarolf@comcast.net
 - f. Renard Lakes, LLC, 12401 Crain Highway, Brandywine, MD 20613, Contact: Andrew Molloy Assistant Project Manager, Ph: (703)335-2255, RenardLakes.com
 7. Recommended Talus Stone Suppliers
 - a. Aggtrans, 7535 Railroad Avenue, Harmans, MD 21077 (410) 766-4242, www.aggtrans.com.
 - b. Rockbridge Stone Products, 1024 Lone Jack Rd, Glasgow, VA 24555, www.rockbridgestone.com

1.8 DELIVERY, STORAGE AND HANDLING

- A. Refer to DIVISION 01 for overall material handling requirements.
- B. In addition, the following provision is established: Material should not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall or is frozen. Soil should be handled only when the moisture content is within the moisture range specified in 329115, Part 1.
- C. Store and handle packaged materials in strict compliance with manufacturer's instructions and recommendations. Protect all materials from weather, damage, injury and theft.
- D. Sequence deliveries to avoid delay. On-site storage space is extremely limited and shall be permissible only with written notice from the owner. Deliver materials only after preparations for placement of planting soil have been completed.
- E. Prohibit vehicular and pedestrian traffic on or around stockpiled planting soil.
- F. Blended soil mixes that are to be stockpiled longer than two weeks shall not be placed in mounds greater than ten feet high. If soil stockpiles greater than ten feet high are present longer than two

weeks then the contractor shall break down and disperse soil so that mounds do not exceed the ten foot height restriction for longer than two weeks. Ten-foot high stockpiles that are in place longer than three months shall be aerated by rolling over or moving.

- G. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.

1.9 MOCK-UPS

- A. General: Mock-ups are required for subgrade preparation and soil placement and must be approved by the Soil Scientist or Landscape Architect. If a mock-up is not approved by the Soil Scientist or Landscape Architect the Contractor shall provide additional mock-ups as required, at no cost to the Owner and until an approved mock-up is obtained. Mock-ups must be approved before soil placement is begun. Approved mock-ups shall be considered the accepted practice for designated soils. The mock-up shall be built in a location as directed by Landscape Architect and at a location that will become part of the final work, unless otherwise noted. A field testing agency is required and should be equipped with the means to conduct field density testing on placed soils. The Contractor shall be equipped with acceptable compaction tools.
- B. Subgrade Preparation Mock-up: The subgrade shall be ripped or scarified according to the procedures outlined in Part 1 and Part 3, tested for infiltration capacity and recompressed prior to the installation of Planting Soils.
- C. The contractor shall document methods and equipment of stripping and stockpiling existing topsoil without commingling the topsoil with the underlying subgrade, as well as storage meeting specification parameters. (if required).
- D. Plant Bed Soil Mock-up: Upon acceptance of all materials and prior to installing Horticultural Subsoil and Planting Bed Soil, the Contractor shall construct mock-up in a designated area. Build mock-up of Horticultural Subsoil and Planting Bed Soil in a bed to allow the Landscape Architect or Soil Scientist to review the installation methods. Approved materials include drainage layer, Horticultural Subsoil, and Planting Bed Soil as specified. Moisture content of all soils must be compliant with this section.
- E. Sand Based Structural Soil Mock-up: Upon acceptance of all materials and prior to installing Sand-Based Structural Soil, the Contractor shall construct mock-up on site in a designated area. Build mock-up of Structural Soil that will support Pavement to allow the Landscape Architect or Soil Scientist to review the installation methods. Approved materials include drainage layer, Sand-Based Structural Soil, 3/4" Crushed Stone and Aeration Pipe as specified. Moisture content of the Sand-Based Structural Soil must be compliant with this section.
- F. Bioinfiltration Profile Mock-up: Upon acceptance of all materials and prior to installing the Bioinfiltration Soils, the Contractor shall construct mock-up on site in a designated area. Build mock-up of Bioinfiltration Planting Soil and Bioinfiltration Subsoil in a bed to allow the Landscape Architect or Soil Scientist to review the installation methods. Approved materials include drainage layer, Bioinfiltration Planting Soil and Bioinfiltration Subsoil. Moisture content of all soils must be compliant with this section.

- E. Habitat Soils with Graded Aggregate Stone Mulch Mockup: Upon acceptance of all materials and prior to installing Horticultural Subsoil and Planting Bed Soil, the Contractor shall construct mock-up in a designated area on a slope of approximately seven percent. Build mock-up of Horticultural Subsoil and Planting Bed Soil with Graded Aggregate material over the Planting Bed Soil in a bed to allow the Landscape Architect or Soil Scientist to review the installation methods. Approved materials include drainage layer, Horticultural Subsoil, and Planting Bed Soil as specified. Moisture content of all soils must be compliant with this section.
- F. Steep Slope Habitat Soils with Crusher Run Aggregate Stone Mulch Mockup: Upon acceptance of all materials and prior to installing Horticultural Subsoil and Planting Bed Soil, the Contractor shall construct mock-up in a designated area with a slope of approximately 30%. Build mock-up of Horticultural Subsoil and Planting Bed Soil with Crusher Run Aggregate in a bed to allow the Landscape Architect or Soil Scientist to review the installation methods. Approved materials include drainage layer, Horticultural Subsoil, and Planting Bed Soil as specified. Moisture content of all soils must be compliant with this section.

1.10 PROJECT/SITE CONDITIONS

- A. Soil Moisture Content
 - 1. Contractor shall not move, blend or grade soil when moisture content is so great that excessive compaction will occur, nor when it is so dry that dust will form in the air or that clods will not break readily, nor when it is frozen. Apply water, if necessary, or allow drying to bring soil moisture between 60% of optimum moisture content (OMC) on the dry side of optimum and optimum moisture content as determined by ASTM D698 for compaction, grading and plantings. All Planting Soils must be at or below OMC for placement and compaction.
 - 2. Field Soil Moisture Screening Test
 - a. Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
 - b. If the soil will not retain shape, it is too dry and shall not be worked.
 - c. If the soil retains shape and will not crumble, it is too wet and shall not be worked.
 - d. If the soil glistens or free water is observed when the sample is patted in the palm of hand the soil is too wet and shall not be worked.
 - e. Field Moisture Screening Test is a qualitative guideline test shall not be used for compliance to Specification Requirements.
 - f. Applicable field method for soil moisture content testing shall be by ASTM 4959 - Determination of Water Content of Soil by Direct Heating

1.11 ACCEPTANCE

- A. Request for Acceptance: In writing, request Landscape Architect's and Soil Scientist's inspection for acceptance at least 10 days in advance of preferred inspection date. Do not request inspection for acceptance until work is 100% complete and in compliance with the Contract requirements.
- B. Final Acceptance: Final Acceptance shall be the day on which the project is 100% complete and accepted by the Landscape Architect and Owner, including "Punch List" items. Maintenance and Warranty work shall commence at Final Acceptance.

1.12 WARRANTY AND MAINTENANCE

- A. Warranty: Provide written warranty agreeing to remove and replace work that exhibits defects in materials or workmanship. Defects shall include settlement, poor drainage, anaerobic soils, compacted soils or any other conditions that are detrimental to healthy plant growth. Length of Warranty shall be two years from Final Acceptance.
- B. Contractor shall begin maintenance immediately after placement. Contractor shall repair slope erosion, remove silt and clay deposits in low areas, maintain soil levels around plant root balls and soil saucers, and monitor irrigation rate and frequency to maintain soil moisture content within horticultural sustaining limits.

PART 2 - PRODUCTS

2.1 BASE COMPONENTS

- A. Soil Performance Criteria
 - 1. All soil blends specified below shall meet all parameters as noted.
 - a. Soil blends shall be free-draining. Achieving minimum saturated hydraulic conductivity value (SHCV) for each blend is of paramount importance. SHVC for each soil blend is specified below.
 - b. Soil blends shall not be over-compacted: compliance with in-place compaction value for each soil blend is of paramount importance. Compaction value for each soil blend is specified below.
- B. General
 - 1. All planting mix material shall fulfill the requirements as specified and be tested to confirm the specified characteristics.
 - 2. Samples of individual components of planting soil mixes in addition to blended plant mixes shall be submitted by the Contractor for testing and analysis to the approved testing laboratory. Comply with specific materials requirements specified.
 - a. No base component material or soil components for plant mixes shall be used until certified test reports by an approved soils laboratory have been received and approved by the Landscape Architect and Soil Scientist.
 - b. As necessary, make all soil mix amendments at any time until completion.
 - 3. The Landscape Architect and Soil Scientist may test at their discretion all soil samples for Quality Control and Quality Assurance. If samples fail to be compliant with specifications, the Contractor shall pay all testing fees.
- C. Soil Samples: Contractor is responsible for paying costs for testing. Submit 1 gallon planting soil samples in two phases. Submit samples concurrent with horticultural soil test reports in both phases. Submit as Phase One, planting soil base components for approval. Only after approval of Phase One components, submit as Phase Two, soil blend test batches for approval. After approval of test batches submit as Phase Three production stockpile test results. All reports must be from recent analyses, less than 90 days old, and represent materials that are available for delivery to the site.
 - 1. Phase One Submittals of Planting Soil Base Components:
 - a. Base Loam
 - b. Compost
 - c. Coarse Sand for Blends and for Drainage Layer (if required)

2. Phase Two Submittals of test batch Planting Soils: mixing and batching of soils shall be produced with the same equipment and in the same manner as production stockpiles will be produced for Phase Three.
 - a. Planting Bed Soil
 - b. Sand based Structural Soil
 - c. Horticultural Subsoil
 - d. Bioretention Planting Soil
 - e. Bioretention Subsoil
3. Phase Three Submittals shall be identical to Phase Two Submittals and be conducted for each 200 cubic yards of soil material prepared for the project site. After three consecutive compliant tests, the Contractor may increase the interval of testing to 500 cubic yards.
4. Submit reports for each of the above samples: Submit sample from each proposed source for testing and approval. Deliver samples to both the testing laboratory and the project soil scientist and pay costs. Send report directly to Owner's Representative.
5. Soil Sample Submittals: Sampling shall be done by the Contractor. The size of the samples and method of sampling shall be as follows: Samples shall be representative of the material to be brought to the site. Each sample shall be a Composite Sample, which consists of 5 separate sub samples taken from a minimum of (5) different locations at each source and mixed together to make the test sample.
6. The Contractor shall schedule this testing in order to permit reasonable time for testing, evaluation, and approvals prior to scheduled shipment and installation. Allow for a minimum of 4 weeks to perform testing and obtain approvals.

D. Imported Base Loam

1. The Contractor shall supply Base Loam from off-site sources. Base Loam as required for blending with other components shall be a naturally occurring soil formed from geologic soil-forming processes without admixtures of sand or organic matter sources (composts). Base Loam shall be free of subsoil, Horizon B and C soils, large stones, earth clods, sticks, stumps, clay lumps, roots or other objectionable, extraneous matter or debris. Base Loam shall also be free of quack-grass rhizomes, Agropyron Repens, and the nut-like tubers of nutgrass, Cyperus Esculentus, and all other primary noxious weeds. Base Loam shall not be delivered or used for planting while in a frozen or muddy condition. Base Loam for mixing shall conform to the following grain size distribution for material passing the #10 sieve.

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	---	100
18	85	100
35	70	95
60	50	85
140	36	53
270	32	42
0.002mm	3	6

2. The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 8 or less ($D80/D30 < 8$).
3. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
4. The organic content shall be between 4.0 and 8.0 percent by weight.
5. pH shall be between 6.0 and 7.4.

6. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium, Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, organic matter content, acidity (pH) and buffer pH. Test reports shall be reviewed for phytotoxic high levels or extreme deficiencies.

E. Sand

1. Sand for Drainage Layer (if required) and Soil Mixes shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, surface coatings, limestone, mica, calcareous materials and deleterious materials with the following gradation, for material passing the #10 Sieve.

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	--
18	60	80
35	25	45
60	8	20
140	0	8
270	0	3
0.002mm	0	0.3

2. Maximum size shall be one half-inch largest dimension.
3. The maximum retained on the #10 sieve shall be 10% by weight of the total sample.
4. The ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.0 or less ($D70/D20 < 3.0$).
5. pH of Sand shall be 7.2 or less, and shall produce no reaction in an acid test.

F. Leaf Yard Waste Compost

1. Organic Matter for amending planting soil and stripped existing topsoil shall be a stable, humus-like material produced from the aerobic decomposition and curing of leaves and yard waste, composted for a minimum of one year (12 months). The Leaf Yard Waste Compost shall be free of debris such as plastics, metal, concrete or other debris. The leaf yard waste compost shall be free of stones larger than ½-inch, larger branches and roots. Wood chips over 1" in length or diameter shall be removed by screening. The compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management practices in conjunction with addition of fertilizer and other amendments as applicable, with no visible free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests.
 - a. The ratio of carbon to nitrogen shall be in the range of 12:1 to 25:1.
 - b. Stability shall be assessed by the Solvita procedure. Protocols are specified by the Solvita manual (version 5.0). The compost must achieve a maturity index of 6 or more as measured by the Solvita scale. Stability tests shall be conducted by Woods End Laboratories, Augusta, Maine.
 - c. Organic Content shall be at least 20 percent (dry weight). One hundred percent of the material shall pass a 1/2-inch (or smaller) screen. Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight. Organic content shall be determined by weight loss on ignition for particles passing a number 10 sieve.
 - d. pH: The pH shall be between 6.5 to 7.2 as determined from a 1:5 soil-distilled water suspension.

- e. Salinity: Electrical conductivity of a one to five soil to water ratio extract shall not exceed 2.0 mmhos/cm (dS/m).
- f. Nutrient content shall be determined by the Soil Testing Laboratory or equivalent laboratory and utilized to evaluate soil required amendments for the mixed soils. Chemical analysis shall be undertaken for Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Magnesium, Iron, Manganese, Lead, Soluble Salts, Cation Exchange Capacity, soil reaction (pH), and buffer pH.
- g. Compost shall not contain phytotoxic residual herbicide levels or other oil or hazardous materials (OHM) above levels established for soils used in residential applications.

2.2 NON-SOIL MATERIALS

- A. AASHTO #57 Crushed Stone (3/4") (alternate) Stone Mulch Material. Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Crushed Stone shall comply with AASHTO #57.
- B. AASHTO #6 Crushed Stone (1/2") Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Crushed Stone shall comply with AASHTO #6.
- C. AASHTO #7 Crushed Stone (3/8") Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Crushed Stone shall comply with AASHTO #7.
- D. AASHTO #8 Crushed Stone (5/16") Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Crushed Stone shall comply with AASHTO #8.
- E. AASHTO #9 Crushed Stone (No. 4) Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Crushed Stone shall comply with AASHTO #9.
- F. Washed AASHTO #10 Crushed Stone (No. 4) Stone mulch material must be reviewed and accepted for rock type, source, composition, size and angularity.
 - 1. Washed Crushed Stone shall comply with AASHTO #10.
- G. Perforated Underdrainage Pipe with Filter Fabric
 - 1. Planting underdrain pipe shall be ADS Single Wall Corrugated Polyethylene Pipe with filter fabric, manufactured by ADS Company, Columbus, OH 43221, or approved equal. Pipe shall be manufacturer's standard perforated configuration of suitable strength for the intended use. Jointing shall be made using manufacturer's standard snap coupling type fittings.
 - 2. Filter Fabric Covering for Corrugated Piping: Piping shall be factory-fitted with a filter fabric covering around piping. Filter fabric shall be Drain Sock filter fabric manufactured by ADS Company, Columbus, OH 43221, or approved equal.
 - 3. In all installations of Planting Underdrainage Pipe with Filter Fabric, Sand as specified herein shall surround the pipe on all sides at least two inches thick and as shown on the Drawings.

- H. Underdrainage Panel Pipe with Filter Fabric (if required)
 - 1. Drainage Pipe shall be 12" width AdvanEdge Pipe by Advanced Drainage Systems (ADS), 12" J-Drain MVP1 by JDR Enterprises or approved equal.
 - 2. In all installations of Underdrainage Panel Pipe with Filter Fabric, Sand as specified above shall surround the pipe on all sides at least two inches thick and as shown on the Drawings, except in cases where Panel Pipe is installed in crushed stone or on protection board. See Drawings.
- I. Non-perforated Underdrainage Pipe
 - 1. Pipe: Pipe shall be ADS Single Wall Corrugated Polyethylene Pipe, manufactured by ADS Company, Columbus, OH 43221, or approved equal.
 - 2. Pipe shall be manufacturer's standard non-perforated configuration of suitable strength for the intended use.
 - 3. Jointing shall be made using manufacturer's standard snap coupling type fittings
- J. Perforated Aeration Pipe and Cap
 - 1. Aeration pipe shall be 4-inch ADS Single Wall Corrugated Polyethylene Pipe, manufactured by ADS Company, Columbus, OH 43221, or approved equal. Pipe shall be manufacturer's standard perforated configuration of suitable strength for the intended use. Jointing shall be made using manufacturer's standard snap coupling type fittings.
- K. Non-perforated Aeration Pipe
 - 1. Aeration pipe shall be 4" ADS Single Wall Corrugated Polyethylene Pipe, manufactured by ADS Company, Columbus, OH 43221, or approved equal. Pipe shall be manufacturer's standard non-perforated configuration of suitable strength for the intended use. Jointing shall be made using manufacturer's standard snap coupling type fittings.
 - 2. Aeration Pipe Cap (alternate, see Irrigation Plans): Provide metal pipe cap, Zurn Z400B Type 'B' Round Strainer with heel proof square openings and secured grate, provided by Zurn Industries, 1801 Pittsburgh Avenue, Erie, PA, Tel: 855.663.9876, www.zurn.com, or approved equal.
- L. Filter Fabric
 - 1. Filter fabric shall be Mirafi 140N (<http://www.mirafi.com>) or approved equal.
- M. Erosion Control Mat shall be Geocoir 400 available from Belton Industries, or approved equivalent, and shall be installed according to the manufacturer's instructions at slopes of 3:1 or greater as shown on the Plans.
 - 1. GeoCoir 400 is available from Belton Industries.
 - 2. Erosion Control Mat shall be installed according to manufacturer's recommend practices, using manufacturer supplied hardware/staples/ties.
 - 3. Soils to be protected with Erosion Control Mat shall be compressed to the Specified compaction ranges and checked for compaction level prior to installing Erosion Control Mat.
- M. Sand and Gravel
 - 1. Free-draining sand and gravel borrow shall consist of inert, hard, durable stone and coarse sand, free from loam, clay, mica, surface coatings and deleterious materials and shall conform with the following gradation:

U.S. Sieve No.	Percent Passing by Weight	
	Minimum	Maximum
3 inch	100	-
1/2 inch	60	-
# 4	40	100
# 50	8	28
# 200	0	5

2. As a chinking layer above $\frac{3}{4}$ -inch crushed stone, Sand and Gravel borrow shall be placed in one lift not more than four inches thick before compaction. Compaction shall be by vibration to a density between 90 and 95% Standard Proctor. Saturated hydraulic conductivity of the sand and gravel shall be not less than 30 inches per hour according to ASTM D2434 when compacted to a minimum of 95% Standard Proctor, ASTM 698.

2.3 SOIL AND BLENDED MATERIALS

- A. Uniformly mix ingredients by either windrowing/tilling on an approved hard surface area or by processing through a screener. Organic matter shall be maintained moist, not wet, during mixing. Amendments shall not be added unless approved to extent and quantity by the owner and additional tests have been conducted to verify type and quantity of amendment is acceptable. Percentages of components, unless otherwise noted, will be established upon completion of individual test results for components of the various mixes. Approximate mixing ratios are provided, but may require adjustment, depending on the final materials. As necessary, the contractor shall adjust suggested ratios to produce compliant blends.
- B. Planting Soil Mixes specified below are based on blends of Base Loam with approved organic matter and sand. After component percentages are determined by the Contractor, each planting soil mix shall be tested for physical and chemical analysis under 1.7 of this Specification Section.
- C. Planting Bed Soil
 1. Planting Soil shall consist of a blend of approximately one-part by volume of Sand, one part by volume of Base Loam and one part by volume of Leaf Yard Waste Compost (1S:1L:1C). Blending of the components shall be carried out with earth moving equipment or screener prior to placement. The components shall be blended to create a uniform mixture as determined by the Landscape Architect. The final mix shall conform to the following gradation requirements for material passing a Number 10 sieve.

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	-
18	85	95
35	60	85
60	42	65
140	21	44
270	18	24
0.002mm	2	5

2. Maximum size shall be one-half inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
3. The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 8.0 or less, (D80/D30 <8.0). Tests shall be by combined hydrometer and wet sieving in compliance with ASTM 6913 or ASTM D7928.

4. The final mix shall have an organic content between 5.0 and 7.0 percent by weight.
5. pH shall be 6.0 to 7.0
6. The final mix shall have a saturated hydraulic conductivity of not less than 2.0 inches per hour according to ASTM D2434 when compacted to a minimum of 85 percent Standard Proctor.
7. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, organic matter content, acidity (pH) and buffer pH.

D. Horticultural Subsoil

1. Imported Horticultural Subsoil shall consist of a blend of approximately two-part by volume of Sand, one part by volume of Base Loam (2S:1L). The following gradation for material passing a Number 10 Sieve shall be achieved in the final mix.

U.S. Sieve Size Number	Minimum	Maximum
10	100	--
18	85	95
35	55	80
60	30	60
140	20	33
270	12	17
0.002mm	1	3

2. Maximum size shall be one half-inch largest dimension. The maximum retained on the #10 sieve shall be 10% by weight of the total sample.
3. The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 6.5 or less, (D80/D30 <6.5).
4. The final mix shall have an organic content between 2.0 and 3.0 percent.
5. The final mix shall have a saturated hydraulic conductivity of not less than 2.5 inches per hour according to test procedure ASTM D2434 when compacted to a minimum of 92 percent Standard Proctor ASTM D698.
6. Chemical analysis shall be undertaken for Ammonium Nitrogen, Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, organic matter content, acidity (pH) and buffer pH.
7. pH shall be 6.0 to 7.0.

E. Sand Based Structural Soil (SBSS)

1. Base Loam, Sand and Compost, each as specified above, shall be combined in an approximate mix ratio of four parts by volume Sand to one part by volume Imported Base Loam to one and one half part by volume Compost (4S:1L:1.5C) to create a uniform blend which meets the following requirements.
2. Gradation for Material Passing the Number 10 Sieve:

U.S. Sieve Size Number	Minimum	Percent Passing Maximum
10	100	--
18	68	90
35	38	63
60	18	39
140	9	18

- | | | |
|---------|---|----|
| 270 | 8 | 10 |
| 0.002mm | 1 | 2 |
3. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
 4. Ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.2 or less. (D70/D20 <3.2)
 5. Saturated hydraulic conductivity of the mix: not less than 6 inches per hour, according to ASTM D2434 when compacted to a minimum of 92% of Standard Proctor MDD, ASTM 698.
 6. Organic content: between 2.5 and 3.5 percent by weight.
 7. The pH shall be between 6.0 and 7.0.
 8. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.
 9. After approval of the above horticultural testing, conduct Standard Proctor Test (ASTM 698) to obtain maximum dry density and optimum moisture content values.

F. Bioretention Planting Soil

1. Base Loam, Sand and Yard Waste Compost, each as specified above, shall be combined in an approximate mix ratio of three parts by volume Sand to one part by volume Base Loam to one part by volume Compost (3S:1L:1C) to create a uniform blend which meets the following requirements.
2. Gradation for Material Passing the Number 10 Sieve:

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	--
18	70	90
35	42	75
60	24	40
140	13	20
270	10	13
0.002mm	2	4

3. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 15% by weight of the total sample.
4. Ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 4.2 or less. (D70/D20 <4.2)
5. Saturated hydraulic conductivity of the mix: not less than 4 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 88% Standard Proctor, ASTM 698.
6. Organic content: between 2.0 and 3.0 percent by weight.
7. The pH shall be between 6.0 and 6.5.

G. Bioretention Subsoil

1. Bioretention Subsoil shall meet the requirements of Bioretention Soil above except that the percentage of compost shall be reduced to create a blend that has an Organic Content between 1.0 and 2.0 percent by weight.

H. Sand Compost Mix

1. Sand Compost Mix shall consist of a 50/50 blend of approved sand and compost for use in amending existing in place soils in tree protection zones and other soil restoration areas as directed by the Planting Consultant, Soil Scientist and Landscape Architect. Additional testing is not required provided the sand and compost are accepted by the Design Team.
- I. Graded Aggregate Crushed Stone Blend Stone Mulch
 1. Graded Aggregate shall consist of a blend of equal parts by volume AASHTO Crushed Stone Numbers 6, 7, 8 and 9, plus one-half part by volume washed AASHTO Crushed Stone Number 10. The Soil Scientist shall review a physical sample of the blend and may require adjustments to the blend component amounts.
- J. Eight-Inch Crusher Run Talus Stone Mulch
 1. Eight-Inch Crusher Run shall be washed, eight-inch maximum size evenly graded, angular, crushed stone material from a rock crushing operation or a blend of crushed stones graded evenly from eight inch angular stones to quarter-inch crushed stone. The blend must be approved for gradation and angularity by the Soil Scientist.
- K. Washed Stone Dust Talus Stone
 1. Stone Dust Surfacing shall consist of Stone Dust, as specified herein, and of the same material as talus stone which has been washed to remove the finer portion of the material and to achieve the following gradation:

U.S. Sieve No.	% Passing by Weight	
	Minimum	Maximum
1/4 inch	100	--
# 10 sieve	60	90
# 20 sieve	25	55
# 40 sieve	5	25
# 100 sieve	0	12
# 200 sieve	0	3

PART 3 – EXECUTION

3.1 COORDINATION

- A. Verify that all Submittals and Test Results required herein have been reviewed and accepted by the Soil Scientist.
- B. Refer to Division 01.
- C. Coordinate activities with other project Contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement of planting soil mixes. Report disturbances to Soil Scientist and Landscape Architect and implement corrective measures as necessary.
- D. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify Landscape

Architect in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, elevations, previous work, and conditions. The Contractor shall not place any planting soil until all work in adjacent areas is complete and approved by the Landscape Architect and Soil Scientist.

- E. Examination of Subgrade: The subgrade shall be examined by the Contractor prior to the start of soil placement and planting. Any deficiencies shall be noted and related to the Landscape Architect in writing prior to acceptance of the subgrade by the Landscape Contractor. Deficiencies include, but shall not be limited to the following:
 - 1. Construction debris present within the planting areas.
 - 2. The subgrade is at incorrect elevations for installing the designed soil profile
 - 3. Subgrade not compacted as specified.
- F. Planting Soil Preparation: Refer to Part 2 of this Section for planting soil and mixtures. Examine soil and remove foreign materials, stones over 1/2", and organic debris over 2" in length. Mix-in fertilizers and amendments as required by tests and as approved by the Landscape Architect and Soil Scientist. All preparation and mixing shall be accomplished when the soil moisture content is less than field capacity. If lime is to be added, it shall be mixed with dry soil before fertilizer is added and mixed.

3.2 EXCAVATION AND REMOVAL

- A. Refer to Section 312000 – Earth Moving
- B. The Contractor is responsible for carefully delineating the limits of work, along with excavating and removing the materials to the elevations shown on the plans to accommodate the new soil profile.
- C. Stripping, stockpiling and re-use of existing topsoil (if required)
 - 1. The extent of existing in-place soils shall be carefully delineated in the field and then stripped and stockpiled without incorporation of the underlying subsoil or other undesirable soils. The stripped topsoil must then be tested in accordance with this Section. If the stockpile is greater than 6 feet tall, the pile shall be rolled over every 3 months to increase aeration, to further homogenize, and to prevent weed growth.

3.3 MIXING OF PLANTING SOIL MIXES

- A. Planting mixtures shall be produced with equipment that blends together each component in a thorough and uniform manner.

3.4 SUBGRADE PREPARATION, INSPECTION AND PERCOLATION TESTING

- A. At all planted areas, after subgrade levels have been reached, the Landscape Architect or Soil Scientist shall observe de-compaction and preparation of the subgrade according to this Section and inspect soil conditions to evaluate subsurface drainage conditions. Heavy Site Subgrade Compaction Mitigation is not required in areas of drainage layer.

- B. In areas with no drainage layer, coordinate the following scarification work to eliminate subgrade compaction when located in Planting areas. Maintain 12" clearance from any underground utilities during subgrade de-compaction.
1. Heavy Site Subgrade Compaction Mitigation:
 - a. Heavily compacted subgrade areas such as, but not limited to, temporary parking areas, material stockpile areas, temporary roadways, construction areas and areas around structures and other similar areas.
 - b. Prior to establishing the final subgrade, these areas shall be dug up or ripped to a depth of (18) inches to break up the soil hard pan, then re-compacted with two passes of the tracks of a wide track bulldozer size D-6 or smaller, or other approved equipment.
 2. General Site Subgrade Compaction Mitigation for all general Planting areas that are not heavily compacted and would be mitigated as specified in Item 1 above:
 - a. Immediately prior to placing Planting Soil, the entire subgrade shall be loosened to a minimum depth of 8-inches using the teeth of a backhoe or other suitable equipment, then re-compacted with two passes of the tracks of a wide track bulldozer size D-6 or smaller, curled bucket of an excavator, or other approved equipment. Vibratory compaction of subgrade in planted areas is prohibited.
- C. After Subgrade has been scarified as described above, it shall be recompressed by the tracks of a small exactation equipment, curled bucket of an excavator, static rolling or other accepted means. Verify the subgrade passes water at or greater than the minimum requirement.
- D. Remove all stones or debris greater than 6" in any dimension from the subgrade prior to placing Planting Soils.

3.5 BACKFILLING OF PLANTING SOIL LAYERS

- A. Planting Soil Placement Preparation:
1. Verify that the underdrainage system has been installed and accepted.
 2. Notify the Landscape Architect and Soil Scientist of soil placement operations at least seven calendar days prior to the beginning of work.
 3. The Landscape Architect will stake locations for trees and shrubs during placement of the planting soils.
 4. After subgrade compaction the upper few inches shall be scarified before placement of planting soil.
- B. Placement of Sand Drainage Layer (if required)
1. Sand Drainage layer shall be placed in conformance with the Drawings and shall be graded smooth and parallel to the finish grades.
 2. Sand Drainage layer shall be compacted to with 2 passes of a vibratory plate compactor to approximately between 90 and 94 percent Standard Proctor.
- C. Placement of all Horticultural Soils
1. Placement of all Planting Soils and plant stock shall be placed simultaneously to prevent excessive traffic over soil lifts and the final grade so as to prevent the creation of undesirable soil compaction. The Landscape Architect will stake trees during placement of the planting soils. Soil backfill around the plant root ball shall be layered in the same depth and sequence as the surrounding soil profile. Compaction due to moving and

- placement of plants, removal of excess soils or from any other operation including foot traffic shall be decompacted.
2. All Planting Soils shall be placed in lifts not to exceed 8 inches in thickness and compacted to meet minimum and maximum requirements as specified below. The surface of each compacted lift shall be scarified by raking or other approved methods to a minimum depth of one-inch prior to placement of the following lift.
 - a. Horticultural Subsoil shall be compacted to between 84 and 86 percent Standard Proctor, except on the Habitat area Horticultural Subsoil shall be compacted to between 86 and 88 percent Standard Proctor
 - b. Soils beneath the rootballs shall be compacted to between 88 and 92 percent Standard Proctor to create a firm pedestal and prevent settlement of the rootballs.
 - c. Planting Bed Soil shall be compacted to between 83 and 85 percent Standard Proctor except in the Habitat Area Planting Bed Soil shall be compacted to between 85 and 87 percent Standard Proctor.
 - d. BioInfiltration Soil shall be compacted to between 83 and 85 percent Standard Proctor.
 - e. BioInfiltration Subsoil shall be compacted to between 84 and 86 percent Standard Proctor.
 - f. In all cases, the soil being placed shall be in a dry to damp condition. No wet soils shall be placed. All testing of in-place density for planting soil shall be made according to ASTM methods or by the Soil Scientist with a compaction probe.
 3. All Planting Soils should never be moved or worked when wet or frozen.
 4. The Contractor shall place barricades as required to prevent any unnecessary compaction of planting soil from vehicles, equipment, or pedestrian traffic.
 5. As required, percolation tests of all Planting Soils shall be performed using Turf-Tec IN2-W Infiltrometer utilizing manufacturer's operating instructions, or via the Perforated Canister Method.
 - a. In-place infiltration tests shall be carried out at a rate of one test per 1,000 square feet for both the subgrade and each type of placed horticultural soil, or at direction of Landscape Architect or Soil Scientist
 - b. Landscape Architect or the Owner's Representative may direct additional testing in locations subject to compaction or adverse Contractor operations.
 - c. Placed planting soils exhibiting noncompliant percolation values shall be removed or restored to compliant conditions.
 - d. In-place field tests must meet or exceed Saturated Hydraulic Conductivity standards specified in Part 2 for each blend.
 - e. If test results are less than specified standards, the Landscape Architect and Soil Scientist will evaluate possible solutions including removal of the soil blend and installation of compliant blend soil. Any repair/replace operation by the Contractor shall be at no additional charge.
 6. Sand-Based Structural Soil shall be spread in lifts not greater than eight inches and compacted with a minimum of three passes of vibratory compaction equipment to a density between 92 and 96 percent Standard Proctor Maximum Dry Density. Stop work and notify Soil Scientist if more than 8 passes are required to achieve minimum density requirement.
 - a. Prepare Mock-Up of initial Sand Based Structural Soil Installation as provided in this Specification. After approval of the Mock-Up, all subsequent installation of Sand Based Structural Soil shall be placed according to approved methods.

- b. A medium to large sized vibratory plate compactor should be used to compact Sand Based Structural Soil. Moisture content of Sand Based Structural Soil should be as close to optimum moisture content (as determined by Standard Proctor Test) as possible for best results.
 - c. Rake the surface of each accepted lift of Sand Based Structural Soil to break the surface glaze caused by the compaction equipment, prior to placing subsequent lifts.
 - d. Density testing for Sand Based Structural Soil must be by the following acceptable Density Test Methods: ASTM D1556 Density of soil and rock in place using Sand Cone Method or ASTM D6938 Nuclear Methods after ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Density testing shall be conducted at a minimum of one test for each plant bed for each lift. Geotechnical testing agency must be on-site to conduct soil moisture and density tests during installation of Sand Based Structural Soil. ASTM 1556 Sand Cone method is the default test and preferred.
 - e. Sand-Based Structural Planting Medium shall be placed in 8" lifts to a minimum depth of two feet within the areas shown on the Drawings, except as otherwise indicated.
 - f. A minimum of six-inches of ¾- inch crushed stone shall be placed over the Sand-Based Structural Planting Medium in areas shown on the Plans.
 - g. Aeration piping shall be placed within the crushed stone layer above Sand Based Structural Soils. Aeration Piping shall be connected to open air connections at the locations shown on the Plans. Open air connections shall be covered with an aeration grate and sump as shown on the Plans.
 - h. Install irrigation soil moisture sensors at the time of SBSS installation, or at the direction of the irrigation consultant.
- 7. In-place infiltration tests shall be carried out at a rate of one test per 1,000 square feet for both the subgrade and each type of placed horticultural soil, or at direction of Landscape Architect or Soil Scientist
 - 8. Landscape Architect or the Owner's Representative may direct additional testing in locations subject to compaction or adverse Contractor operations.
 - 9. Placed planting soils exhibiting noncompliant percolation values shall be removed or restored to compliant conditions.
 - 10. In-place field tests must meet or exceed Saturated Hydraulic Conductivity standards specified in Part 2 for each blend.
 - 11. If test results are less than specified standards, the Landscape Architect and Soil Scientist will evaluate possible solutions including removal of the soil blend and installation of compliant blend soil. Any repair/replace operation by the Contractor shall be at no additional charge.

3.6 HABITAT LANDSCAPE PLANT INSTALLATION AND PLACEMENT OF STONE MULCH

- A. For Habitat areas with slopes at or less than 20% set rootballs approximately three inches below final grades which is approximately three inches above the level of installed Planting Soils. Place Plant Bed Soil around the rootballs to create a two horizontal to one vertical slope from the top of the rootball to the placed Plant Bed Soil.
 - 1. Place pervious root barrier over planting soils.

2. Place rounded peastone in a three-inch thick and three-inch wide band around the trunks of trees and shrubs. For perennials and grasses, place three inches of Medim to Coarse Sand, as specified, over the rootballs. Place three inches of Graded Aggregate over the remainder of rootballs for shrubs and trees, and for all plantings increase to six inches away from rootballs.
 3. Wet the Graded Aggregate and compact with a small vibratory plate compactor.
- B. For Habitat areas with slopes greater than 20% set rootballs approximately three inches below final grades, which is approximately nine inches above the level of installed Planting Soils.
1. Place pervious root barrier over planting soils.
 2. Place rounded peastone in a three-inch thick and three-inch wide band around the trunks of trees and shrubs. For perennials and grasses, place three inches of Medim to Coarse Sand, as specified, over the rootballs. Place three inches of Crusher Run Aggregate over the remainder of rootballs for shrubs and trees, and for all plantings increase to six inches away from rootballs.
 3. Wet the Crusher Run Aggregate and compact with a small vibratory plate compactor

3.7 SOIL RESTORATION AND AMENDMENT IN TREE PROTECTION ZONES

- A. Soil Restoration and Amendment within tree protection zones must be conducted by use of an air spade. Air spading shall be carried out under the supervision of a certified arborist with a minimum of five years experience with air spading techniques.
- B. Air spading for Soil Restoration and Amendment shall be carried out within the entire area of all tree protection zones and shown on the plans and within a minimum distance of ten feet of the tree stem for any other existing trees to remain. The depth of air spading and soil amendment shall be determined by an arborist to loosen as much soil as possible without root damage but should be a minimum of six inches unless the arborist determines a lesser depth is appropriate.
- C. After initial soil loosening, three inches of Sand-Compost Blend, as specified, shall be spread over the loosened soils. Mycorrhizal fungi and other amendments as recommended by the arborist should also be spread. The amendments should then be incorporated into the loosened soil by air spading, generally creating a six to eight-inch layer of blended soil.
- D. After air spading is complete, the area shall be compressed with one pass of the tracks of small construction equipment as approved by the Arborist or Soil Scientist. Following compression, the areas shall be thoroughly watered to wet the entire air spaded depth.

3.8 PROTECTION AND ADJUSTMENTS

- A. Protect newly graded areas from traffic, freezing and erosion. Keep free of trash, debris or construction materials from other work
- B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or compacted due to subsequent construction operations or weather conditions. Scarify or remove and replace material to a depth as directed by the

Landscape Architect; reshape and re-compact at optimum moisture content to the required density.

- C. Where settling occurs, before final acceptance or during the warranty period, remove finish surfacing, backfill with additional approved material, compact to specified rates, and restore any disturbed areas to a condition acceptable to the Owner.
- D. Existing soils and placed horticultural soils shall be protected from wheeled equipment by installation of steel plates or protection mats. Should travel across existing soil or placed horticultural soils be necessary, the protection plan shall be submitted for approval by the Landscape Architect and Soil Scientist seven days prior to travel.

3.8 COORDINATION AND EXCESS MATERIALS

- A. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.
- B. Excess Planting Soil Mixture and Materials: Remove the excess planting soil mixture and materials from the site at no additional cost to the Owner unless otherwise requested.

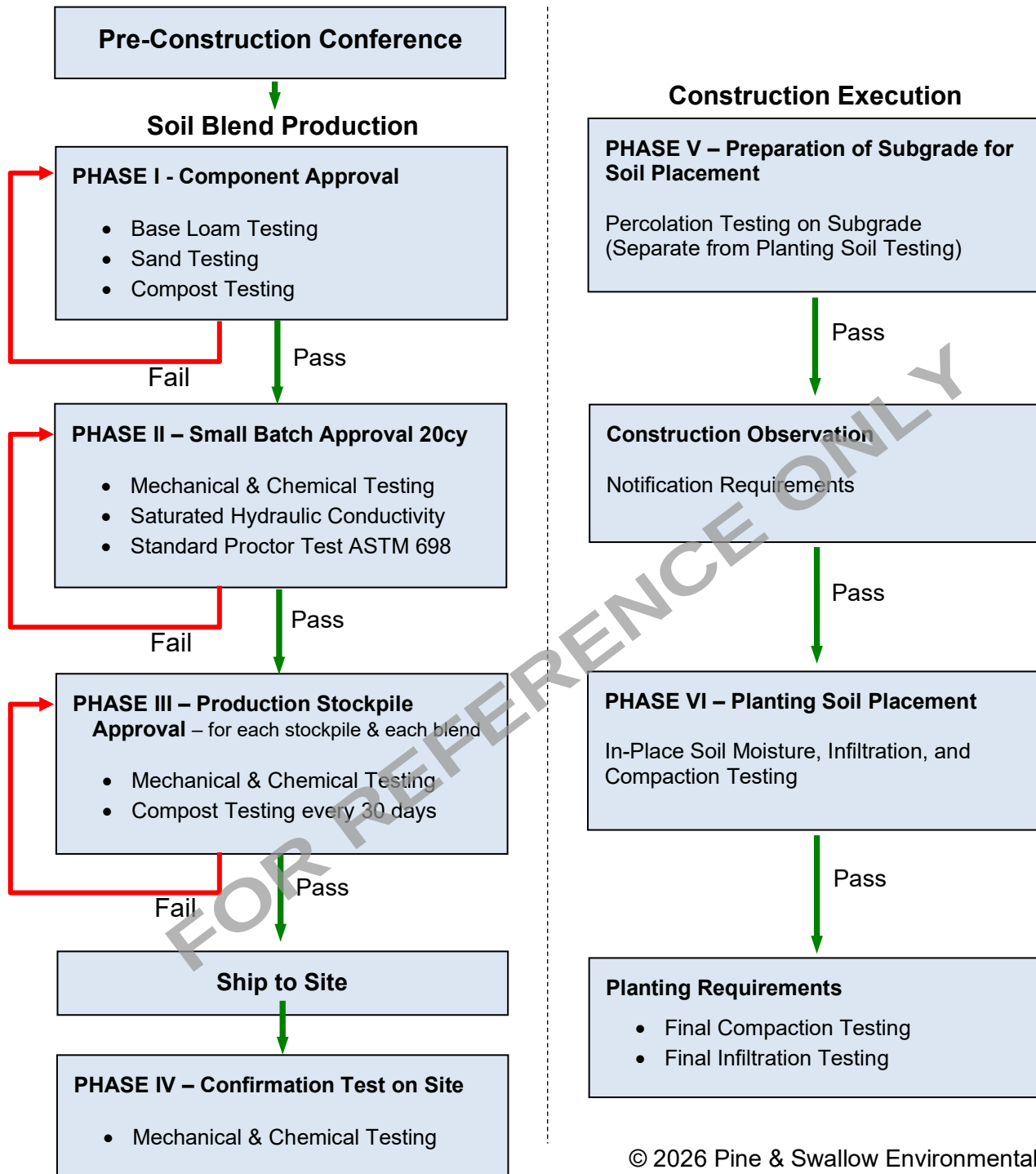
3.9 POST-INSTALLATION TESTING

- A. In-place density testing is required in all areas. Placed planting soils must be inspected for compaction level by the Soil Scientist or by the following acceptable Density Test Methods: ASTM D1556 Density of soil and rock in place using Sand Cone Method or ASTM D6938 Nuclear Methods after ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- B. Density and moisture content testing for Sand-Based Structural Soil must be by ASTM D6938-10 Nuclear Methods, after ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Density testing shall be conducted at a minimum of one test for each lift in each plant bed or a minimum of every 300 square feet.
- C. Placed Planting Soils must be capable of infiltrating water at the minimum rate provided in this Specification for each type of planting soil

END OF SECTION 32 9115

© 2026 Pine & Swallow Environmental

APPENDIX: PLANTING SOIL TESTING PROTOCOL



SECTION 32 9119 - LANDSCAPE GRADING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Topsoil placement.
- B. Finish grading.

1.2 RELATED REQUIREMENTS

- A. Section 32 9219 - Seeding.

1.3 REFERENCE STANDARDS

- A. ASTM D5268 - Standard Specification for Topsoil Used for Landscaping and Construction Purposes; 2023.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Planter Soil: shall meet the following conditions:
 - 1. Soils shall be free from any materials detrimental to plant growth and will be of a pH normal range for plant growth pH 5.5-7.0.
 - 2. Soils shall contain no stones or other organic or inorganic debris greater than 1/2 inch in diameter.
 - 3. Soils shall possess from 6% to 12% organic matter by weight per ASTM D 2974.
 - 4. Mechanical analysis shall fall within the following particle ranges:
 - a) Sand (0.0502 mil dia.)Range: 30-70%Avg. Percentage: 50%
 - b) Silt (0.002-0.05 mil dia.)Range: 20-50%Avg. Percentage: 35%
 - c) Clay (less than 0.002 mil dia.)Range: 5-25%Avg. Percentage: 15%
 - d) 95% of the topsoil shall pass a 2.0 sieve
 - 5. Soils shall have a maximum soluble salt content of 75 parts per million.
- B. Fill Soil
 - 1. Fill soil shall be obtained from required excavations on site. The selection, blending, routing, and disposition of material in the various fills shall be subject to approval by the landscape architect. Fill materials shall contain no frozen soil, sod, brush, roots, or other perishable material. Rock particles larger than 1" shall be removed prior to compaction of the fill.
- C. Amended Existing Soil
 - 1. Zoo to preform a soil test to determine what compost needs to be added.

PART 3 EXECUTION

3.1 TOPSOIL PLACEMENT

- A. Uniformly distribute and spread topsoil.
- B. Compacted Topsoil Thickness: Place as indicated on drawings.

3.2 FINISH GRADING

- A. Maintain profiles and contour of subgrade.
- B. Remove roots, weeds, rocks, and foreign material while spreading.
- C. Maintain uniform topsoil thickness.
- D. Lightly compact placed topsoil.

END OF SECTION

SECTION 32 9300 – EXTERIOR PLANTINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Tree and shrub plantings.
 - 2. Plug plantings.
 - 3. Herbaceous perennials, ornamental grasses, groundcover and vine plantings.
 - 4. Plant procurement.
 - 5. Plant mulch.
 - 6. Aggregate maintenance edge.
 - 7. Metal edging.
 - 8. Staking and guying.
 - 9. Jute mesh slope stabilization.
 - 10. Maintenance.
 - 11. Warranty replacements.
- B. Related Requirements:
 - 1. Section 01 5639 "Temporary Tree and Plant Protection" for protecting, trimming, pruning, repairing, and replacing existing trees to remain that interfere with, or are affected by, execution of the Work.
 - 2. Section 31 1000 "Site Clearing" for stripping on-site topsoil.
 - 3. Section 31 2000 "Earth Moving" for mass grading of the site.
 - 4. Section 32 8000 "Irrigation System" for design-build irrigation systems.
 - 5. Section 32 8400 "Planting Irrigation" for turf and planting irrigation systems.
 - 6. Section 32 9100 "Topsoil" for lawns and plant mixture amendment.
 - 7. Section 32 9280 "Vegetation Control" for control of weeds or eliminating established lawn areas before planting.
 - 8. Section 33 4600 "Subdrainage" for plant bed and tree pit underdrainage system.

1.2 REFERENCES AND REGULATORY REQUIREMENTS

- A. Hortus Third, The Staff of the L.H. Bailey Hortorium. 1976. MacMillan Publishing Co., New York.
- B. ASTM International, as referenced herein as ASTM.
- C. American Standard for Nursery Stock, as referenced herein as ANSI Z60.1 (current edition). Where there is a conflict between the information in this Section and ANSI Z60.1, this Section shall govern.
- D. United State Department of Agriculture (USDA), Plant disease and insect control Phytosanitary and Export Certifications.
- E. United States Composting Council, Seal of Testing Assurance (STA), Procedures for sampling and testing as outlined in the Test Methods for the Examination of Composting and Compost (TMECC) protocols.

1.3 DEFINITIONS

- A. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with a ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- B. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than the minimum root spread according to ANSI Z60.1 for type and size of plant required.
- C. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
- D. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
- E. Finish Grade: Elevation of finished surface of planting soil.
- F. Mycorrhizal Inoculum: Fungi either introduced or naturally occurring in the soil that increase plant roots growth and ability to absorb nutrients and water.
- G. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.
- H. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. Pests include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- I. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- J. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- K. Root Production Method (RPM): A trademark technology referred to as root production method for a variety of tree and shrub species resulting in a dense fibrous root system for smaller sized plants.
- L. Single Central Leader: A single central dominant leader branch, free of secondary co-dominant stems that would compete with the central leader, either naturally occurring or professionally trained in the nursery with no stem deformities.

- M. Specimen Plant: Exceptionally heavy, symmetrical, and tightly knit, growth, superior in form, with properly spaced branching.
- N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees at or below the soil surface.
- O. Subgrade: The surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- P. Sheared Evergreen: Any evergreen tree or shrub that has been heavily trimmed or pruned to remove the natural shape of the plant. An evergreen tree grown at a "Christmas tree farm" is typically sheared.
- Q. Young Plants: Lining out stock, seedlings generally sold within the wholesale trade for continued cultivation.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

A. Product Data:

1. Plant procurement verification:
 - a. Within 4 weeks following the execution of the Agreement between the Owner and Contractor, submit vendor purchase order, invoice or bill of lading for each plant species showing sizes, quantities and root treatment.
 - b. Provide digital photos of all plant materials. Photos must depict the entire size and condition of the plant and include a scale rod or other measuring device to show scale. For species where more than 20 plants are required, include a minimum of three photos that show the average plant, the best quality plant, and the worst quality plant to be provided. Label each photograph with the plant name, plant size, and name of the growing nursery.
 - c. The Contractor may request the Landscape Architect to provide nursery visits for the purpose of reviewing and tagging plant materials. The Contractor shall compensate the Landscape Architect for said services.
 - d. Substitutions shall not be permitted without written approval from the .
2. Metal edging and accessories.
3. Jute mesh.
4. Soil amendments: Provide information on composition and source of all soil amendments. Include test results for compost and peat.
5. Mycorrhizal inoculum.
6. Fertilizer.
7. Antidesiccants: Include product label and manufacturer's application instructions.
8. Maintenance edge aggregate gradation analysis.
9. Maintenance edge aggregate separation fabric.
10. Organic Mulch: Include product source and composition.
11. Predator barrier fencing and tree guard.
12. Staking and guying materials and ties.
13. Root barrier for bamboo control.

B. Source Quality Control:**1. Samples:**

- a. Organic Mulch: 1 quart by volume in sealed plastic bag labeled with composition of materials and source of mulch. Provide an accurate representation of color, texture, size, and organic makeup.
- b. Mineral Mulch: 1 quart by volume in sealed plastic bag labeled with composition of materials and source / product name. Provide an accurate representation of color, texture, and size. Note, multiple samples of available products may be required for color selection by the Owner.
- c. Maintenance edge aggregate: 1 quart by volume in sealed plastic bag labeled with composition of materials and source / product name. Provide an accurate representation of color, texture and size. Note, multiple samples of available products may be required for color selection by Owner.

2. Test Report:

- a. Topsoil: Test reports including fertilization recommendations for lawns and plant materials. Refer to Section 329100 "Topsoil".

3. Certifications/Licenses:

- a. Phytosanitary Certification: Plant material Inspection Certificates required by Federal, State or other governing authority at the time of plant material verification identified above.
- b. License certificate(s) for pesticide applicator.

4. Nursery Requirements:

- a. Plants shipped to the site as B&B must originate from a licensed plant nursery with a current Phytosanitary certification. Field collected plants will not be permitted.
- b. Plant digging shall comply with the following requirements:
 - 1) Digging shall not occur more than 4 months in advance of plant installation.
 - 2) Plants dug during the spring digging season must be planted in advance of the fall digging season of that same year.
 - 3) Plants dug during the fall season must be planted during the same season and will not be permitted for spring planting.
 - 4) No plants that have leafed out shall be dug.
 - 5) Plants with root systems that have grown through the original jute wrapping will not be permitted. This included all plants that have a second jute covering over the root ball.
 - 6) Jute wrapping that is heavily decayed or torn with exposed roots and loose root ball soil will not be permitted.
- c. Wrap tree trunks with protective material in advance of digging.

C. Field Quality Control:

1. Project Work Schedule: Within 4 weeks following the issuance of the Notice to Proceed, submit a project work schedule to the Landscape Architect indicating dates for delivery, installation, and Substantial Completion for all landscape work. The Schedule shall be comprehensive and address procurement, delivery, and installation of irrigation, planting and seeding/sodding areas of the site. For large site, the schedule shall reflect a phased installation and shall include support graphics required to identify this phased approach. Refer to Part 1.10 below for a complete list of schedule requirements.

2. Maintenance Schedule: Prior to the issuance of Substantial Completion, submit a detailed typewritten approach and schedule for the warranty maintenance of all landscape activities outlined under Part 3.13 of this section. Coordinate landscape maintenance with other applicable Sections (, Irrigation) and combine all maintenance activities into one plan of action. The schedule shall be comprehensive and shall be the basis for monthly payment during the maintenance period.
3. Irrigation Plan: Within 4 weeks following the issuance of the Notice to Proceed, submit a detailed typewritten approach and schedule that outlines watering requirements for maintaining the landscape as described herein. The Irrigation Plans shall be submitted in conjunction with the Maintenance Schedule. The plan shall address how the irrigation system will be operated during the warranty period, frequencies and durations that will be established to provide the correct watering rates for plants and lawns, inspection protocols and frequencies and winterization procedures. In locations where no automatic irrigation system has been installed, describe means, methods and frequencies for hand watering. If the automatic irrigation system is inoperative or not present, provide an approved temporary irrigation system or hand water from a source approved by the COTR. Supply all water and equipment at the Contractor's expense from a source approved by the COTR. Reliance on natural precipitation will only be allowed with provision of recorded data from a rain gauge located within a 2-mile radius of the project site. The schedule shall be comprehensive and shall be the basis for monthly payment during the maintenance period.
4. Maintenance Report Forms: Using the approved Maintenance Schedule and Irrigation Plan as the framework for all maintenance activities (plant maintenance, lawn maintenance and irrigation operations). The Contractor shall provide detailed maintenance report forms for each site visit. The reports shall be completed by the on-site maintenance superintendent performing the work prior to leaving the site and shall be submitted monthly as back-up to each invoice. Office prepared reports will not be permitted and payment for this work will only be made by the Owner when proof of completed specified maintenance has been provided. Each report shall include the following:
 - a. Date of activity.
 - b. Length of time on site (start time and finish time).
 - c. Name and signature of the maintenance superintendent.
 - d. Number of personnel performing the work.
 - e. Site climatic conditions (rain, wind, temperature, etc.)
 - f. Detailed description of maintenance activities performed by area.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Include list of at least three similar projects completed in the last 5 years by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
2. Provide resumes of field technician (foreman) responsible for managing the purchase and installation of all materials. Separate resumes shall be provided for the planting, seeding, irrigation and maintenance technicians.
3. ISA certification for arborist.

1.7 QUALITY ASSURANCE

A. Qualifications:

1. The Contractor shall be a company specializing in exterior landscape, irrigation installations and maintenance, having a minimum 5 years' experience in projects of the scope and scale being specified.
2. Installer's field technician: The installer shall provide a full-time supervisor on site when work is in progress.
3. Maintenance field technician: The maintenance activities for all landscape areas shall be performed by skilled employees of the landscape installer. Subcontractors specializing in landscape and turf maintenance will not be permitted unless approved in writing by the Landscape Architect.
4. Pesticide applicator: State licensed, commercial.
5. Tree and shrub pruning: ISA certified Arborist.

B. Substitutions:

1. It is the Contractor's responsibility to locate and secure all plant materials and to verify their availability well in advance of installation through the timely Action Submittal process identified above. Failure to comply with this requirement shall not be a reason for making substitutions. Furthermore, it may be necessary to purchase specified plants from multiple nurseries and from out-of-state sources providing said sources are within the same hardiness zone as the site.
2. Substitutions of plant materials will not be permitted unless authorized in writing by the Landscape Architect. If proof is submitted in writing that a plant specified is not obtainable, the Landscape Architect may assist in identifying alternate sources or substitutions.
3. Plants of larger size may be used if approved and if root balls meet ANSI Z60.1 for the increased size. Adjustments will be made at no additional cost to the Owner. Approval of smaller size plant materials shall require a corresponding credit to the contract price subject to Owner pre-approval.

C. Measurements: Measure plants according to ANSI Z60.1. Do not prune to obtain required sizes.

1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches above the root flare for trees up to 4-inch caliper size, and 12 inches above the root flare for trees larger than 4-inch caliper.
2. Other Plants: Measure with stems, petioles, and foliage in their normal position.
3. Plants pruned to compensate for transplanting shock will not be accepted if overall height and spread do not meet the specified dimensions after pruning.

D. Plant Material Observation: Landscape Architect may observe plant material either at place of growth or at site before, during or after planting for compliance with requirements for genus, species, variety, cultivar, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1.8 DELIVERY, STORAGE, AND HANDLING

A. General:

1. Packaged Materials: Deliver packaged materials in original unopened containers showing weight, analysis and name of manufacturer. During shipment and storage on site, protect materials from breakage, moisture, heat or other damage.
2. Store materials only in locations approved by the Owner. No storing or mixing of pesticides or herbicides is allowed on site.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
2. Provide erosion-control measures to prevent erosion or displacement of bulk materials; discharge of soil-bearing water runoff; and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
3. Accompany each delivery of bulk materials with appropriate certificates.

C. Plant Materials:

1. Do not bend, stack or bind plants in a manner that damages bark, breaks branches or root systems, deforms root balls or destroys natural shape.
2. Transport plants in closed vehicles or with the entire load properly covered to protect from drying winds, heat, freezing or other exposure that may be harmful. Schedule shipping to minimize on-site storage of plants. Closed vehicles shall be adequately ventilated/refrigerated.
3. Labels: Prior to shipping, each plant or bundle of like variety and size shall be labeled with legible weatherproof tags indicating the correct name and size of plant.
4. Stock shall not be shipped until the planting preparations have been completed. If planting is delayed more than 24 hours after delivery, set plants and trees in filtered sun or shade, protect from weather and mechanical damage, and keep roots moist.
 - a. Heel-in bare-root stock. Pack root system in wet straw, hay, or other suitable material to keep root system moist until planting. Soak roots in water for two hours immediately prior to planting. Plants with dry roots will be rejected. Any bare-root plants requiring sweating to break dormancy must have this procedure carried out before plants arrive onsite.
 - b. Set balled stock on ground and cover ball with soil, or bark mulch.
 - c. Do not remove container-grown stock from containers before time of planting.
 - d. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly wet condition.
5. Store bulbs, corms, and tubers in a dry place at 60 – 65 degrees F until planting.
6. Handle plants at all times in accordance with the best horticultural practices. Lift B&B materials from the bottom of the ball only; do not roll the plants. Plants handled otherwise will be subject to rejection. Balled and burlapped plants which have cracked or broken balls are not acceptable and shall not be planted. Plants with mechanical damage, deformation or breakage will not be accepted and are to be replaced at the Contractor's expense.

1.9 SCHEDULING

A. Work Schedule:

1. Upon authorization to proceed with the work, submit a project work schedule indicating the dates of each of the following items:
 - a. Submittal schedule.
 - b. Tagging of plants in nurseries.

- c. Delivery of other materials to the site.
 - d. Staking of plant locations on the site.
 - e. Delivery of plant material to the site.
 - f. Planting.
 - g. Substantial Completion of the work.
 - h. Maintenance period.
2. Update schedule monthly to reflect progress of the work.

B. Planting Season:

1. Materials shall be installed during planting seasons normally recognized in the job locality. Soils shall be in workable condition and not frozen.
2. USDA Hardiness Zone 7:
 - a. B&B and container grown deciduous trees and shrubs, planting season shall be from March 15 through May 15 and from October 1 through November 30.
 - b. Containerized perennials, planting season shall be from March 15 through May 15 and from September 15 through October 30.
 - c. Coniferous evergreen plants, planting season shall be from March 15 through May 15 and from October 1 through November 1.
 - d. Broadleaf evergreen plants, planting season shall be from March 15 through May 15 and from September 1 through October 15.
 - e. Bare root woody plants, planting season shall be in early spring dormant period, prior to April 1 but no later than full leaf-out of existing woody plants in project area.
 - f. Bare root woody plants and aquatic tuber and root stock only in spring from March 15 through approximately May 15 but no later than full leaf-out of existing woody and aquatic plants.
 - g. Bulbs, corms and tubers from October 1 through November 15 and from March 15 through May 15. Spring vs. fall planting is species dependent and Contractor shall comply with seasonal limitations identified on the plant list included on the drawings.
3. If special circumstances warrant installation outside the normal planting season, submit a written request to the Landscape Architect describing conditions and stating the proposed variance. Planting outside the planting season could extend warranty obligations and will be dependent upon the extent of the variance.
4. Weather limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.

1.10 WARRANTY AND ACCEPTANCE

A. Substantial Completion:

1. The Substantial Completion inspection shall occur for the entire landscape and only one Notice of Substantial Completion will be issued. Phased approvals will not be permitted. Following the inspection, the Landscape Architect will issue a punch list identifying all work requiring completion or correction.
2. The Contractor shall complete all punch list items within 2 weeks of its issuance. All repairs and plant replacements shall occur at no additional cost to the Owner.
3. Substantial Completion will be provided for all planting areas complying with the following:
4. Landscape Architect approval of all specified submittals.

5. The work shall be 100 percent complete (including all site preparation , earthwork , plant mixture installation , plantings , native seeding, irrigation, and clean-up), and ready for inspection.
 6. After receiving a Notice of Substantial Completion warrant and maintain all plantings in accordance with Part 3.13 of this Section in a vigorous, well-kept condition until Final Acceptance.
- B. Final Acceptance:
1. The Contractor shall complete all punch list items within 2 weeks of its issuance. All repairs and plant replacements shall occur at no additional cost to the Owner.
 2. Final Acceptance will be based upon Owner approval and the work having:
 - a. Been well maintained with all landscape plantings in a healthy growing condition free of disease and insect problems.
 - b. All maintenance items completed and documented by Contractor through maintenance report forms.
 3. Final Acceptance and the end of the warranty period for the landscape will occur only after all punch list items have been satisfactorily completed and the site is left in the condition specified under Cleanup and Protection.
- C. Warranty and Maintenance Period:
1. The end of the warranty and maintenance period shall be:
 - a. October 31 ““ one year following fall Substantial Completion.
 - b. June 30 ““ one year following spring Substantial Completion.
 2. Prior to and during the warranty and maintenance period, replace any plants that are damaged, dead, or, in the opinion of the Landscape Architect, are unhealthy, or have lost more than 25 percent of their natural shape due to dead branches, excessive pruning or improper maintenance. Rejected plant materials shall be removed from the site immediately after being rejected and legally disposed off-site. Replacement plants shall be installed within 2 weeks following the inspection unless otherwise agreed to in writing by the Owner.
 3. Only one replacement of any plant is required after Substantial Completion, except for losses due to failure to comply with specified installation and/or maintenance requirements. Failures include but are not limited to: infestation of crowns of perennials or ornamental grasses with invasive weeds due to failure to maintain beds, insufficient watering operations, herbicide damage, structural failures such as trees not remaining upright, and faulty performance of tree stabilization or watering devices.
 4. Make replacements in accordance with the original specifications, plant list, planting details, and notes. Fully restore areas damaged by replacement operations to their original and specified condition.
 5. The Contractor will not be held responsible for defects resulting from neglect by Owner, abuse or damage by others, or unusual phenomena or incidents beyond landscape installer's control which result from floods, hail storms, winds over 100 miles per hour, fires or vandalism, unless Contractor has not completed specified installation or maintenance in a manner that could have protected the landscaping from these phenomena.

6. If, in the opinion of the Landscape Architect, it is advisable to extend the warranty and maintenance period for an additional growing season, the Contractor will be notified of such requirement by the Owner. Improper planting and/or failure to perform and document the specified maintenance in accordance with contract requirement shall be the basis for extending the period of establishment for an additional growing season. All specified maintenance and warranty requirements will be required during this extended period and all costs shall be the responsibility of the Contractor.

PART 2 - PRODUCTS

2.1 PLANT MATERIALS

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in the Plant List shown on Drawings and with the minimum quality conforming to ANSI Z60.1. Branching on all plants shall be characteristic of the species, well-shaped, full, sound, healthy, vigorous stock of uniform growth and densely foliated when in leaf. All plants shall be free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
 1. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
 2. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Where plant height or spread is indicated with a tolerance, the smaller dimension is the minimum acceptable; the larger dimension represents the maximum permissible. The average dimension of all plants must, at least, equal the average of the tolerance figures shown on the drawings. Spread shall meet the minimum dimension specified in all directions and must be considered as pivoting on center of plant.
 3. Canes on shrubs shall arise at or just below the root crown. Multi-stem and clump form trees shall have branches that arise at or just below the root crown except when approved by the Landscape Architect.
 4. All plants shall have a waterproof legible label securely attached to each plant bearing designation of plant's common and scientific name, including genus, species, and cultivar or variety, when applicable.
 5. Do not prune plants prior to delivery.
 6. Stressed or damaged plants or those not conforming to the specifications shall be subject to rejection by the Landscape Architect at any time during the term of the contract.
- B. Root treatments on all plants shall conform to the following requirements:
 1. Balled and burlapped ("B&B") plants shall have healthy root systems developed by transplanting or root pruning with a firm, natural ball of earth securely wrapped with burlap, bound with cord and wire basket. Root flare shall be visible before planting. Plants with damaged or broken root balls or multiple layers of burlap will not be accepted.
 2. Containers shall be finished landscape grade material having their roots well established in the soil mass. Plants over-established in the container, as evidenced by pot-bound root ends, will not be accepted.

3. Annuals , biennials , perennials , staked vines , groundcover and ornamental grasses shall have well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery. Annuals and biennials shall be in bud but not yet in bloom.
 4. Bulbs, Corms and Tubers: Provide healthy, disease free rot stock of the genus, species, variety and condition listed on the drawing. All plant sizes, grades and weights shall conform to ANSI Z60.1.
- C. Trees: Evergreen and deciduous trees shall have straight single leaders. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch in diameter; or with stem girdling roots will not be accepted. Evergreens shall be unsheared.
1. Trees indicated as specimen shall be exceptionally heavy, symmetrical, and superior in form, branching, and symmetry.
 2. Caliper is the trunk diameter taken at a specified distance above root collar as described in ANSI Z60.1.
 3. Branching height is the distance above ground where balanced branching occurs.

2.2 MULCH

- A. Organic Mulch: Well-composted, finely shredded processed hardwood bark, free from foreign material and fragments in excess of 2 inches in any dimension.
1. Dyed mulch or mulch that is predominantly wood chips will not be accepted.
- B. Leaf Mulch:
1. Fully decomposed, dark, friable, organic material derived primarily from deciduous leaves, with a pH of 6.0–7.0 and organic matter content of at least 40%, applied at 1–3 inches depth as a top dressing.
- C. Mineral Mulch: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:
1. Type, Size, and Color: As indicated in landscape drawings..
- D. Filter Fabric: Synthetic, non-woven, needle-punched geotextile fabric weighing 2 to 4 oz per square yard with a minimum grab tensile strength of 35 pounds and permeability of 0.03 cm/second.

2.3 JUTE MESH

- A. Uniform, open, plain weave fabric of unbleached, single jute yarn having a width of 48 inches, plus or minus 1 inch and durability of 1-2 years. Yarn shall be loosely twisted jute fiber, having an average twist of not less than 1.6 turns per inch, varying in thickness by not more than 1/2 its normal diameter, and averaging 130 pounds per spindle of 14,400 yards. Polymer yarns are not acceptable.
1. Fasteners shall be natural based plastic that is 100 percent biodegradable from microbial activity in accordance with ASTM D5338 or D6400, formed in a T-shaped with barbed heads and shoulders, minimum six inches long, color green and installed per manufacturer's spacing and installation instructions.

2.4 STAKING AND GUYING

- A. Staking (for deciduous trees less than or equal to 3.5-inch caliper, ornamental/understory trees, and evergreens less than or equal to 12-foot height):
 - 1. Tree support stakes shall be a minimum actual size (not nominal) 2 inch x 2 inch hardwood posts free of bark or 3 inch diameter hardwood or cedar posts with bark intact. Posts shall be minimum 8 feet long. Metal fence posts are not permitted unless approved in advance by the [Landscape Architect] <Insert text>.
 - 2. Tree support stakes for Root Production Method trees (RPM) shall be 1 inch x 1 inch hardwood posts free of bark.
 - 3. Wire stays for tree stakes shall be No. 12 to 14 gauge galvanized wire. Polypropylene strapping will not be permitted.
 - 4. Chafing guards shall be fiber-reinforced hose of not less than 1/2 inch inside diameter, color black. Multi-colored hose will not be permitted.
- B. Guying (for deciduous trees greater than 3.5" caliper and evergreen trees greater than 12-foot height):
 - 1. Tree support stakes for guying shall be 2 x 4 hardwood posts 30 inches long or metal fence posts 48" long. Guying stakes shall be driven below grade and not visible.
 - 2. Cable for guying trees shall be 3/16 inch diameter, five strand, galvanized steel wire. Polypropylene strapping will not be permitted.
 - 3. Cable clamps and turnbuckles shall be galvanized, forged steel. Turnbuckles shall be 3/8-inch eye with 6-inch minimum opening.
 - 4. Chafing guards shall be fiber-reinforced hose of not less than 1/2 inch inside diameter, color black. Multi-colored hose will not be permitted.

2.5 TREE WRAP, TRUNK PROTECTION, AND TREE GUARDS

- A. Tree wrap for deciduous trees as noted in Plant List on Drawings shall be 4-inch wide, two-ply, waterproofed crepe Kraft paper with plies cemented together with asphalt. Twine used to secure wrap shall be natural fiber two-ply jute. Tape or plastic twine will not be permitted as a substitution for the jute twine.
- B. Trunk Protection for deciduous shade trees: Corrugated PVC trunk protection, minimum 6" diameter, 5' height minimum.

2.6 WATER

- A. Water shall be available from off-site sources.
- B. Water shall be free of wastewater effluent or other hazardous chemicals. On-site sources of water may be available [based on pumping from the [creek][lake][pond]][from City hydrant with metering and payment by Contractor][insert known source]. Confirm prior to commencing work.

2.7 FERTILIZER

- A. Fertilizers are required at the time of installation and during the warranty/maintenance period. The fertilization program shall be based on soil testing and formulations and rates of application shall be based on test reports provided by the independent testing laboratory.

- B. The independent testing laboratory shall also prepare a custom formulation and rate for each category of plants to be installed and maintained; i.e. trees, shrubs, perennials/ornamental grasses, annuals and bulbs.
- C. Fertilizers shall include organic and inorganic, slow release and water-soluble nitrogen and the percentages shall be based on soil types and the time of year being applied. Fertilizers shall not be applied during the hot summer months unless specific to blooming plants or from mid-summer through the end of the growing season when new plant growth will not harden off prior to the first killing frost.
- D. The fertilizer to be used to amend the soil before planting shall be granular fertilizer that conforms to applicable state and federal regulations, and contains no less than 60 percent slow-release nitrogen.
- E. Fertilizer to be used during the warranty and maintenance period shall be a complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, not less than 30 percent of the nitrogen from a slow release source. Fifty percent of the nitrogen shall be derived from natural organic sources. The formulations shall be as provided by soil test of this Section.

2.8 ANTIDESICCANTS

- A. Water-soluble, biodegradable, non-hazardous emulsion specifically manufactured for agricultural use that will provide a protective film over plant surfaces to limit transpiration yet not interfere with respiration, osmosis, or photosynthesis. Use according to manufacturer's written instructions.

2.9 METAL EDGING

- A. Metal edging shall comply with ASTM A1011/A1011M, sized [3/16 inch thick x 4 inches wide x 16 feet length], made of steel, colored [black], fabricated in sections with stake pockets stamped, punched, or welded to face of sections approximately 30 inches apart, with 3/16 inch x 16 inch stakes, as manufactured by J.D. Russell Co., or approved equal.
 - 1. Accessories shall be from same product line and manufacturer.

2.10 MAINTENANCE EDGE AGGREGATE

- A. Aggregate for maintenance edges shall be: Hard, durable stone, washed free of loam, sand, clay, and other foreign substances, of following type, size range, and color:
 - 1. Type, Size and Color: As indicated in landscape drawings. .
- B. Filter Fabric: Synthetic, non-woven, needle-punched geotextile fabric weighing 2 to 4 oz per square yard with a minimum grab tensile strength of 35 pounds and permeability of 0.03 cm/second.

2.11 BAMBOO ROOT BARRIER

- A. Size, type as indicated in landscape drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. General:

1. Prior to beginning work, examine and verify the acceptability of the project site and notify the Landscape Architect of unsatisfactory conditions or obstructions that do not appear on the Drawings. Do not proceed with the work until unsatisfactory conditions have been corrected or resolved.
2. Verify that no foreign or deleterious material has been deposited in soil within a planting area.
3. Where planting occurs in close proximity to other site improvements, provide adequate protection to all features prior to commencing work. Promptly repair any items damaged during planting operations to their original condition.
4. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
5. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
6. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
7. If plants die or are rejected due to non-conformity to contract requirements, they must be removed from the site immediately and replaced before Substantial Completion.

B. Utilities: Have all underground utilities located by servicing agencies. In the vicinity of utilities, hand-excavate to minimize possibility of damage.

C. Coordination with Other Work:

1. The Contractor shall coordinate work with other contractors or trades to determine the appropriate sequence of landscape installation with respect to other work on the site.
2. Completed work installed out of construction sequence which is subsequently disturbed by the completion of work by other trades shall be repaired by the landscape installer at no cost to the Owner.
3. Maintain grade stakes and layout controls set by others until removal is mutually agreed upon by all parties concerned.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion control measures, if necessary, to prevent erosion or displacement of soils and discharge of soil-bearing water run-off or airborne dust to adjacent properties, natural resources and all pavement surfaces.
- C. Vegetation Removal: Strip and dispose of organic debris and root mat.

3.3 LAYOUT

- A. Accurately lay out each plant location and planting bed edges according to the drawings, using clearly visible painted, labeled stakes or plastic flags. Spray paint continuous lines on bare soil delineating plant bed boundaries. When scaling locations on the drawings, use at least 2 known reference points as layout controls to determine plant locations. Do not proceed with planting operations until locations have been reviewed and approved in writing by the Landscape Architect.
- B. Prior to installation, all plant locations and bed edges must be approved by the Landscape Architect, who may field adjust locations at no additional cost to Owner. Plants installed without layout approval are subject to relocation at Contractor's expense.

3.4 PLANT INSTALLATION

- A. General: Complete all plantings, metal edging and mulching prior to fine grading adjacent seed beds. Keep excavations covered or otherwise protected after working hours and when unattended by Installer's personnel.
- B. Planting Pit Excavation:
 - 1. For individual plant pits in seeded areas, spread seed bed topsoil to the uniform depth and rough grade prior to layout and planting pit excavation.
 - 2. Remove rocks and other unclassified underground obstructions to at least 6 inches below the finished planting depth of the root ball. Trim perimeter of planting pit leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Ensure that root ball will sit on undisturbed base soil to prevent settling. If plant pits are initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
 - 3. If underground utilities or other surface or subsurface obstructions are encountered that cannot be removed, do not proceed with planting operations until alternate planting locations have been selected and approved by the Landscape Architect.
 - 4. Size and configure planting pits in accordance with the planting details. If rotating augers or other mechanical diggers are used, scarify the side walls and bottom of the pit.
 - 5. Where poor soil percolation is probable, test drainage by filling planting pits with 12 inches of water. Record the drainage time for each pit and if, in the opinion of the Landscape Architect, the water does not adequately drain off within 24 hours, install drains or raise plant pits as directed.
- C. Planting Bed Excavation:
 - 1. Refer to Section 311000 "Site Clearing" for vegetation removal and topsoil salvage for reuse in plant mixture.
 - 2. Refer to Section 312000 "Earthwork" for earthwork requirements.
 - 3. [In locations where plant beds are shown on the drawings and earth moving is not required other than achieving the specified plant bed subgrades, excavate plant beds to the depth shown on the planting details. Remove all existing vegetation. Following vegetation removal, top dress plant bed with four inches compost and rototill into upper twelve inches of soil. Lightly compact.
 - 4. Grade subgrade smooth and uniform. Slope to perimeter of plant bed when underdrains are required to collect accumulated water within the bed.

5. Transition from plant bed subgrade to adjacent seed bed subgrade outside the limits of the plant bed to ensure full depth plant bed mixture is provided.
 6. Where plant beds terminate next to pavement surfaces, subgrade transitions shall be 12 inches wide within the plant bed to protect pavement base material from being undermined.
 7. Obtain approval from the Landscape Architect for all subgrades prior to placing plant mixtures. Notify the Landscape Architect at least 48 hours in advance of placing plant mixture.
- D. Mixing and Placing Planting Mixtures:
1. Install planting bed and planting pit mixtures to the specified proportions and depths. On-site mixing of salvaged topsoil with off-site topsoil or amendments shall result in a homogenous blend of all ingredients. Screen all mixture to remove foreign debris and rocks greater than ½ inch diameter prior to placement.
 2. Place planting bed mixture in 6 inch lifts and lightly compact to prevent settlement after planting. Settlement that occurs after planting will require plant removal and the placement of additional plant mixture at the Contractor's expense. When placing mixture in raised planters, set finish grade elevations 2 inches low for mulch placement, if required on Drawings.
 3. Grade planting areas to a smooth, uniform surface plane. Roll and rake, remove ridges, and fill depressions to meet grade.
 4. Before planting, obtain Landscape Architect's approval of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- E. Fertilizing:
1. Prior to or during planting, amend all planting pit and bed mixes by incorporating fertilizer at rates required by soil test reports as specified under Section 329100 "Soil Preparation (Topsoil)". Do not broadcast fertilize over the surface of the soil or onto any plant root ball.
 2. For individual plant pits, incorporate fertilizer into back fill during planting operations. For plant beds, pre-mix fertilizer prior to installation.
- F. Planting and Backfill:
1. Do not plant when the ground is frozen or saturated.
 2. Balled and burlapped plants: Do not use planting stock if root ball is cracked or broken before or during planting operation. Set the plant in the center of planting pit with the crown set at 1 inch above adjacent soil for shrubs and 2 inches above adjacent soil for trees. Root flares shall not be set below adjacent finish grade. Face plant to give the best appearance or relationship to primary views. Cut away burlap, rope, wire or other wrapping materials from the the entire root ball and remove from pit. If plastic wrap or other non-degradable materials are used in lieu of burlap, completely remove them from the root ball before backfilling. Backfill planting pit approximately two-thirds full, add fertilizer, water and allow planting mixture to settle. After the water has been absorbed, complete backfilling and tamp lightly to grade to prevent future settlement and form a watering basin with plant mixture of the size indicated on Plans.

3. Container-grown plants: Remove containers and make at least four vertical cuts one-half to one inch deep around the root ball and thoroughly loosen the roots on the outside of the ball. Plant as specified above for balled and burlapped plants with the additional requirement that container-grown stock shall be planted so that top of container soil is level with surrounding grade, unless the root flare is not at the surface of the container soil. If the root flare is buried, excavate to expose the flare and place as required above in relation to finish grade. Size of root ball must meet ANSI Z60.1 after removal of material. Do not plant higher to account for mulch, as mulch should not cover plant crown.

3.5 SPECIAL PLANTING CONSIDERATIONS:

- A. Mycorrhizal Inoculum:
 1. Rototill 2 granular pounds per 1000 square feet into the top 8 inches of soil for plant beds or as recommended by supplier. Incorporate 1 pound per cubic yard of plant pit backfill as backfill is being placed.
- B. Sloped Plantings:
 1. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball. Complete planting as specified under Part 3.4 F above.
- C. Jute Mesh:
 1. On sloped plantings requiring jute mesh, immediately following placement of plant mixture cover the entire bed area before plant pit excavation and installation of plants. Excavate plant pits and insert plants through mesh by separating the fibers or cutting slits into the fabric, taking care not to destroy the integrity of the mesh as a whole. To minimize the disturbance of the mesh when planting, work from long, lightweight ladders or planks laid parallel to the slope.
- D. Aquatic Plantings:
 1. Predator barrier:
 - a. Immediately install predator barrier in the locations shown on the Plans after planting.
 - b. Install stakes driven 2.5' into the soil at 10' on center intervals around the perimeter of the planted areas.
 - c. Using 25-pound fishing monofilament, firmly connect the monofilament to posts on opposite sides of the planting area via wrapping, stretching, and tying. Avoid parallel lines. Overlap and crisscross as much as possible until each post has at least one attached line. Line shall be suspended 30-36" above the normal water surface elevation. Attach 24" long red or orange survey ribbon to the strings every 24" apart.
 - d. Install perimeter polyethylene fence tight against the hardwood stakes.
 - e. Maintain monofilament and fence in a tight condition until the end of the planting warranty period. At that time, the entire predator barrier system shall be removed and disposed of by Contractor
- E. Perennial Plugs:
 1. Install native seed and erosion mat per Drawings prior to any plug planting.
 2. Set out and space perennials plugs as indicated on drawings with triangular spacing.

3. Prior to planting, biodegradable plant containers shall be split and non-biodegradable containers removed. The root systems of all plants shall be split or crumbed by hand.
4. To install plugs into erosion control mat, cut 'X' into the erosion control mat, pull back corners and excavate hole 2x width of plug and same depth as plug. Install and backfill with topsoil, folding fabric under to hold open at sides of plug plant foliage.
5. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
6. Do not mulch plugs planted within seeded areas.

F. Root Production Method (RPM) Trees:

1. Complete plantings as specified for container grown plants above. Install tree guard and staking in accordance with planting detail.

G. Bare-Root Plants:

1. Prior to planting, remove damaged roots and those running beyond the general root mass. Soak bare root trees and shrubs for two to six hours in water prior to planting. Place bare-root stock in center of plant pit and plant so that the roots are arranged in a natural position, uniformly distributed around the crown of the plant. Carefully work soil mix in around the roots in several layers, watering until puddled and allowing the soil to settle between layers. Maintain plumb while working backfill around roots. Complete planting as specified for balled and burlapped plants above.
2. Tree guards shall be placed around all bare root plant material per manufacturer's instructions and stake securely.

3.6 MULCHING

- A. Uniformly install mulch on all trees and shrub beds to depth shown on Plans within 48 hours of planting.
- B. Keep mulch out of the crowns of shrubs and perennials, at least 3 inches from all tree trunks, and off sidewalks and roadways.

3.7 PRUNING

- A. After planting, prune trees and shrubs to remove all dead, dying, broken, or crossed limbs flush with the ground or main stem leaving no stubs. Do not prune to shape or to compensate for transplanting shock. Retain natural form of the plant type. Prune using standard professional horticultural and arboricultural practices. Remove trimmings from the site.
- B. Employ workers experienced in this type of work.

3.8 WRAPPING

- A. The trunks of deciduous trees as noted for particular species in Plant List shall be wrapped immediately after planting, but not before the condition of the trunks has been inspected and approved by the Landscape Architect. Trim the margins of any abrasions or cuts with a sharp, sterile knife prior to applying wrap.
- B. Wrap trees beginning at the base and extending to the first branches in a spiral pattern with an overlap of half the width of the paper.
- C. Secure the wrapping at the top, bottom and at 18 inch maximum intervals with twine.

3.9 STAKING AND GUYING

- A. Install guying and staking as shown on the details immediately after planting.
- B. Remove and dispose of stakes and guys at the end of the warranty period.

3.10 EDGING

- A. Metal Edge:
 - 1. Install edging as detailed and at all locations shown on Plans, keeping the alignment smooth and continuous without visible deviation from the line or arc being set.

3.11 MAINTENANCE EDGE

- A. Excavate areas receiving maintenance edge to the cross section shown on the details.
- B. Level and compact subgrade and install metal edging and filter fabric as detailed, overlapping ends by 6 inches.
- C. Install aggregate, leveling material with the top of edging.

3.12 CLEANUP AND PROTECTION

- A. Remove excess and waste material daily. When planting has been completed, clear the site of all debris, stockpiles and materials.
- B. Repair any damage to existing landscape, paving or other such features as a result of work related to this contract to its original condition.
- C. Protect landscape work and materials from damage due to landscape operations, and operations by other Contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair or replace damaged landscape work as directed.
- D.

3.13 MAINTENANCE

- A. Provide all maintenance under the supervision of a skilled employee of the landscape installer. The skilled maintenance supervisor shall be: capable of operating the automatic irrigation system controller, conducting plant diagnostics to identify the presence of disease and insect problems and directing a maintenance crew in the performance of horticultural maintenance practices identified below. Maintenance requirements identified below shall be the basis for information to be included in the Maintenance Schedule and Irrigation Plan identified under Part 1.5 of this section and documented under the required Maintenance Report Forms to verify the work has been properly performed.
 - 1. [Failure to perform [and submit factual Maintenance Report Forms] could result in non-payment for said services and require the extension of the warranty and maintenance period an additional year at the Contractor's expense.

- B. Provide all equipment, materials, labor and services to maintain the landscape beginning immediately after each plant is installed and continuing until Final Acceptance and the end of the warranty period. Perform all work under the direct supervision of a technician trained to recognize and treat conditions affecting the establishment and growth of the plants and perform the following:
1. Inspect the entire landscape at least once per week during the growing season and perform needed maintenance promptly.
 2. Irrigation:
 - a. Irrigate all plants to maintain optimum moisture within the root zone. Reoccurring overly dry or wet conditions shall be grounds for rejection of plant material. When using an automatic sprinkler system, the landscape installer responsible for maintenance shall bear full responsibility to set each zone to the correct frequency and duration.
 - b. If the automatic irrigation system is inoperative or not present, provide an approved temporary irrigation system or hand water from a source approved by the COTR. The system shall have the ability to be operated without moving hoses or sprinklers around the site between seeded/planted areas (i.e. system can be set to water one area for the required maintenance period), and may be automated with a timer. Supply all water and equipment at the Contractor's expense from a source approved by the COTR.
 3. All pruning shall be performed by or under the supervision of a certified arborist. Prune only dead wood and broken limbs as identified, in accordance with Part 3.7 - Pruning. Do not shear evergreens or any shrubs unless specifically required to be maintained as a sheared hedge. Maintain the natural shape of trees and shrubs. Plants sheared so that they no longer present their natural shape will be replaced at Contractor's expense.
 4. Maintain stakes and guys taut and in the specified condition. Repair tree wraps if loose, torn or untied.
 5. Maintain all plant beds and tree saucers weed free. Edge shrub and perennial beds and tree rings at least monthly during the growing season, keeping all tree rings to a uniform diameter. Hook mulch monthly and add mulch as needed.
 6. Deadhead perennials, annuals, biennials as necessary during maintenance visits to extend blooming periods.
 7. In early spring – prior to the start of the growing season, cut all ornamental grasses to within 8" of the ground and remove cuttings from the site.
 8. Apply treatments as necessary to keep plants and planted areas free of insects, pests, and disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and herbicides. Treatments include utilizing physical and cultural controls.
 9. Apply antidesiccant to upright conifers and broadleaf evergreens in December through February, at least once per month. In locations subject to high wind or salt spray, install burlap windscreens around spreading conifers and broadleaf evergreens but do not allow burlap to touch the plants.
 10. Collect all litter and debris from plant beds and dispose off-site.
 11. Fertilization:
 - a. Fertilize plant material as recommended by the soil test report.
 12. Remove dead and unacceptable plants as their condition becomes apparent. Make replacements during normal planting schedule season unless otherwise directed by Landscape Architect. Do not wait until end of the warranty period to replace plants unless directed to do so by Landscape Architect.

13. At the end of the warranty period, but prior to Final Inspection, remove all staking, guying, trunk wrap, protection fences, watering bags or saucers, and other accessories and top dress tree rings and beds 1 inch deep with the specified mulch product.

END OF SECTION

FOR REFERENCE ONLY

SECTION 32 9300 - PLANTS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Preparation of subsoil.
- B. Placing topsoil.
- C. New trees, plants, and ground cover.
- D. Relocated trees, plants, and ground cover.
- E. Fertilizer.
- F. Maintenance.
- G. Tree Pruning.

1.2 RELATED REQUIREMENTS

- A. Section 32 9119 - Landscape Grading.

1.3 REFERENCE STANDARDS

- A. ANSI/AHIA Z60.2 - American Standard for Nursery Stock; 2025.

1.4 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

1.5 QUALITY ASSURANCE

- A. Nursery Qualifications: Company specializing in growing and cultivating the plants with three years documented experience.
- B. Installer Qualifications: Company specializing in installing and planting the plants with 5 years documented experience.
- C. Tests and Inspections: Provide test results for chemical and physical characteristics of all items listed under submittals.

1.6 FINAL ACCEPTANCE

- A. General: Work under this section will be accepted by the Owner upon satisfactory completion, including maintenance, but exclusive of replacement of plant materials under the Warranty Period. Upon Final Acceptance, the Owner will assume responsibility for maintenance of the work.
- B. Inspections:
 - 1. Make written request for inspection after planting operations have been completed. Such inspection is for the purpose of establishing the Warranty Period.
 - 2. Submit written requests for inspections to Consultant and Owner at least 14-days prior to anticipated inspection date.

1.7 WARRANTY PERIOD AND REPLACEMENTS

- A. General: Contractor shall warranty that all plants installed under this Contract will be healthy and in flourishing condition of active growth one year from date of Final Acceptance.
- B. Plant Replacements:
 - 1. Plants shall be continuously in thriving conditions free of dead or dying branches and branch tips, and shall bear foliage of a normal density, size and color. All plants not meeting these requirements shall be replaced as required below.
 - 2. Replacements shall closely match adjacent specimens of the same species and shall be subject to all requirements of this specification.

3. At any time during the warranty period and at the end of the warranty period, replace, without cost to the Owner, and as soon as weather conditions permit, all plants not meeting the requirements set forth in this section.
 4. Rejected plants may be retained in place or at the discretion of the Owner, must be removed immediately.
- C. Exclusions to Warranty Replacement:
1. Contractor shall not be held responsible for failures due to neglect by the Owner or vandalism during Warranty Period. Report such conditions to Owner in writing.
 2. Warranty shall not include damage or loss of plant materials caused by fires, floods, freezing rains, lighting storms, winds over seventy-five (75) MPH, or winter kill caused by extreme cold and severe winter conditions not typical of the project site.
 3. Plant replacement during the warranty period shall be limited to one replacement unless the prior plant installation did not meet the requirements of these specifications.

1.8 WARRANTY INSPECTION

- A. General:
1. Hold final inspection with Contractor, Consultant, and Owner at the end of the one-year period.
 2. Contractor will notify the Consultant and Owner 14 days prior to the proposed meeting.

PART 2 PRODUCTS

2.1 PLANTS

- A. Plants: Species and size identified in plant schedule, grown in climatic conditions similar to those in locality of the work.
- B. Basic requirements:
1. Provide the specified plant species except as modified by the substitution procedures.
 2. All Plants will meet the requirements of ANSI Z60.1 for size and condition.
 3. Provide plant materials meeting all requirements of this section.

2.2 SOIL MATERIALS

- A. Topsoil: Type Planting Soil; see Section 32 91 13.

2.3 MULCH

- A. General:
1. Organic materials, locally available.
 2. Suitable for retaining moisture.
 3. Allows the free exchange of water vapor and other gasses between planting soil and the atmosphere above.
 4. Size of wood chips not to exceed 3/4" in size.
- B. Mulch – Physical and Chemical Requirements:

Table:

Property	Test Method	Requirement
pH	TMECC 04.11-A	6.0–8.5
	Elastometric pH 1:5 Slurry Method pH Units	
Soluble Salts	TMECC 04.10-A Electrical	0–10.0
	Conductivity 1:5 Slurry Method dS/m (mmhos/cm)	

Moisture Content	TMECC 03.09-A Total Solids & Moisture at 70+/-5 deg C % Wet Weight Basis	N/A
Organic Matter Content	TMECC 05.07-A Loss-On-Ignition Organic Matter Method (LOI) % Dry Weight Basis	30-100
Maturity	TMECC 05.05-A Germination and Vigor, % Relative to Positive Control Seed Emergence: Seedling Vigor:	N/A/N/A
Stability	TMECC 05.08-B Carbon Dioxide Evolution Rate mg CO ₂ -C/g OM per day	N/A
Particle Size	TMECC 02.02-B Sample Sieving for Aggregate Size Classification % Dry Weight Basis	- 2-in > 99% passing- 3/8-in < 25% passing- 3-in max. length
Pathogen	TMECC 07.01-B Fecal Coliform Bacteria < 1000 MPN/gram dry wt.	< 1000 (Pass)
Pathogen	TMECC 07.01-B Salmonella < 3 MPN/4 grams dry wt.	< 3 (Pass)
Physical Contaminants	TMECC 02.02-C Man Made Inert Removal and Classification: Plastic, Glass and Metal % > 4mm fraction	Combined Total: < 1.0
Physical Contaminants	TMECC 02.02-C Man Made Inert Removal and Classification: Sharps % > 4mm fraction (Sewing needles, hypodermic needles)	None Detected

C. Definitions:

TMECC refers to "Test Methods for the Examination of Composting and Compost," published by the United States Department of Agriculture and the United States Compost Council (USCC).

2.4 SOIL AMENDMENT MATERIALS

- A. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth of plants.
- B. Planting Fertilizer: Containing fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil, as indicated in analysis.
 - 1. Nitrogen: 20 percent. Minimum of 50% of nitrogen derived from slow release ureaformaldehyde Agriform tablets.

- a) Trees and shrubs: 21 gram tablets
 - b) Groundcovers and Aquatic Plants: 5 gram tablets.
- 2. Phosphoric Acid: 10 percent.
- 3. Soluble Potash: 5 percent.
- C. Top-Dress Fertilizer:
 - 1. General:

6-10-8 complete fertilizer, fifty percent of the nitrogen to be derived from natural organic sources or ureaform. Available phosphoric acid shall be from superphosphate, bone or tankage. 50% of the Potash shall be derived from sulfate of potash-magnesium.

 - a) 6% nitrogen
 - b) 10% phosphoric acid
 - c) 8% potash
 - 2. Additives:

Fertilizer shall contain the following additives:

 - a) F.T.E. 2%
 - b) Multitracin 0.5%
 - 3. Gradation:

Fertilizer to meet the following gradation:

 - a) No. 4 sieve retains 0%
 - b) No. 20 sieve retains 65%
 - c) No. 80 sieve retains 100%

2.5 ACCESSORIES

- A. Wrapping Materials: Burlap.
- B. Stakes: Pressure treated wood stakes, 6 foot to 8 foot by 2 inch x 2 inch.
- C. Cable, Wire, Eye Bolts and Turnbuckles: Non-corrosive, of sufficient strength to withstand wind pressure and resulting movement of plant life.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that prepared subsoil and planters are ready to receive work.
- B. Saturate soil with water to test drainage.
- C. Holding plants on site:
 - 1. Plants will / may be held on the project within the limits of work or in a location designated by the Owner.
 - 2. The Contractor takes responsibility for maintaining the plant's health and condition immediately upon each plant's removal from the holding area.

3.2 PREPARATION OF SUBSOIL

- A. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated subsoil.
- C. Scarify subsoil to a depth of 3 inches (75 mm) where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.
- D. Dig pits and beds 6 inches (150 mm) larger than plant root system.

3.3 PLACING TOPSOIL

- A. Spread topsoil to a minimum depth of 4 inches (100 mm) over area to be planted. Rake smooth.
- B. Place topsoil during dry weather and on dry unfrozen subgrade.
- C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
- D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.
- E. Install topsoil into pits and beds intended for plant root balls, to a minimum thickness of 6 inches (150 mm).

3.4 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions.
- B. Apply after initial raking of topsoil.
- C. Mix thoroughly into upper 2 inches (50 mm) of topsoil.
- D. Lightly water to aid the dissipation of fertilizer.

3.5 PLANTING

- A. Set plants vertical.
- B. Remove non-biodegradable root containers.
- C. Set plants in pits or beds, partly filled with prepared plant mix, at a minimum depth of 6 inches (of 150 mm) under each plant. Remove burlap, ropes, and wires, from the root ball.
- D. Place bare root plant materials so roots lie in a natural position. Backfill soil mixture in 6 inch (150 mm) layers. Maintain plant life in vertical position.
- E. Saturate soil with water when the pit or bed is half full of topsoil and again when full.

3.6 PLANT RELOCATION AND RE-PLANTING

- A. Relocate plants as indicated by Architect.
- B. Replant plants in pits or beds, partly filled with prepared topsoil mixture, at a minimum depth of 6 inches (of 150 mm) under each plant. Remove burlap, ropes, and wires, from the root ball.
- C. Place bare root plant materials so roots lie in a natural position. Backfill soil mixture in 6 inch (150 mm) layers. Maintain plant materials in vertical position.
- D. Saturate soil with water when the pit or bed is half full of topsoil and again when full.

3.7 PLANT SUPPORT

- A. Brace plants vertically with plant protector wrapped guy wires and stakes to the following:
 - 1. Tree Caliper: 2 to 4 inches (50 to 100 mm); Tree Support Method: 3 guy wires with eye bolts and turn buckles
 - 2. Tree Caliper: Over 4 inches (100 mm); Tree Support Method: 4 guy wires with eye bolts and turn buckles
- B. Guy and stake in accordance with planting details. Plants shall stand plumb after guying, unless otherwise noted on drawings.

3.8 LAYOUT AND EXCAVATION OF PLANT PITS

- A. Layout:
 - 1. Layout plants or stake positions in locations shown on drawings for Consultant's inspection and approval.
 - 2. Consultant will adjust locations in the field before planting begins.

3. Consultant reserves right to refuse such inspection if, in his opinion, an insufficient number of plants are available on site. All plants specified for each area to be planted must be available for layout .
 4. Plant mixed groupings of understory plants with cluster of the same species in groups of 5, 7, or 9 plants per cluster for natural effect.
 5. Landscape Architect to approve layout prior to planting.
- B. Excavation:
1. Excavate plant pits to the following dimensions:
To a width two and a half times greater in any dimension than rootball, container, or box.
 2. Subsoil Removal:
Separate subgrade soils and remove from planting area during planting operations. Loosen subgrade in pits and beds to a depth of 3-inches (75mm). Thoroughly scarify sides of planting pits.
 3. Backfill with 1:1 mix of planting soil to native soil.

3.9 DRAINAGE, OBSTRUCTIONS AND DETRIMENTAL SOILS

A. Detrimental Soils:

Notify Consultant in writing of any soil or drainage conditions detrimental to growth of plant material.

B. Drainage:

1. Test drainage of 10% of tree and 5% of shrub pits prior to plant installation by filling completely with water. In areas where pits retain water as specified below test the remaining plant pits.
2. Conditions permitting the retention of water for more than twenty-four (24) hours shall be brought to the attention of the Consultant.

C. Shrubs in areas retaining water shall be mounded a minimum of 150mm (six-inches) above final grade and trees shall be mounded a minimum of 300mm (twelve-inches) or a height sufficient to place bottom of rootball above groundwater level. Feather soil away from root ball at a slope no greater than two feet horizontal to one foot vertical.

D. Obstructions:

1. If rock, underground utilities or foundations, tree roots or other obstructions are encountered in the excavation of plant pits, alternate locations may be selected by Consultant.
2. Where locations cannot be changed, submit cost required to remove obstructions to a depth of not less than six inches (6") below the required pit depth.
3. Proceed with work only after written approval of Consultant

3.10 PLANT PLACEMENT

A. Pre-planting Period:

1. Protect plants at all times from sun or drying winds or freezing.
2. Plants that cannot be planted immediately on delivery shall be kept in the shade, protected from wind, and maintained at each species optimum moisture content.

B. Container Removal:

1. Canned stock shall be removed carefully after container has been cut on two sides with approved cutter.
2. Do not lift or handle container plants by tops, stems, or trunks at any time.
3. After removing plant from container, scarify side of rootball to prevent root-bound condition.

- C. Plant Placement:
 - 1. Use Planting Soil Mix to backfill plant pits.
 - 2. Place plant and rotate to best advantage from principal viewpoints of adjacent walkways.
 - 3. Set plant plumb and brace rigidly in position until planting soil has been tamped solidly around the ball and roots.
 - 4. When plant pits have been backfilled approximately 2/3 full, completely flood with water containing rooting hormone, before installing remainder of the planting soil to top of pit.
 - 5. Firm soil to eliminate air pockets.
- D. Planting Fertilizer Placement:
- E. Evenly distribute tablets in plant pits when backfilled 2/3 as follows:
 - 1. Deciduous Trees - two 21 gram tablets per caliper inch.
 - 2. Deciduous Shrubs - two 21 gram tablets per foot of height.
 - 3. Evergreen Trees and Shrubs - one 21 gram tablet per foot of height or spread.
 - 4. Groundcovers, vines, and herbaceous plants - one 5 gram tablet per plant.
- F. Burlap Removal:
 - 1. When 1/2 backfilled, cut ball ties, remove burlap from top and sides, cut and adjust to prevent formation of air pockets.
 - 2. Do not pull burlap from under the balls.

3.11 MULCH PLACEMENT

- A. Finish Grading:

Smooth planting area to conform to specified grades after full settlement has occurred.
- B. Mulch Placement:

Mulch all pits and beds with a 50mm (2-inch) layer of mulch.
- C. Rooting Hormone:

Saturate ground cover areas with water containing rooting hormone immediately after completion of planting.

3.12 PRUNING

- A. General:

Prune plants only after planting, in accordance with standard horticultural practice, and only at the direction of the Consultant.
- B. Pruning of existing trees:

Pruning to remove dead wood, broken or damaged branches shall be done as directed by and under supervision of the Project Arborist or Consultant.

3.13 TOP DRESS FERTILIZER

- A. First Application:

Immediately after completing mulching of shrub and ground cover beds, apply Top Dress Fertilizer at the rate of seven (7) pounds per 1000 feet.
- B. Subsequent Application:
 - 1. Beginning April 15 and extending to August 15 of the first full growing season or one month after first application for planting completed during the first growing season, make monthly applications of Top Dress Fertilizer to all shrub and ground cover beds at the rate of seven (7) pounds per 1000 square feet.

2. In planting areas for which Final Acceptance occurs during the first growing season continue the top dress fertilizer application at specified rates and intervals for a period of 1 year from First Application until warranty inspection.

3.14 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

END OF SECTION

FOR REFERENCE ONLY

SECTION 33 1415 – SITE WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Water Distribution Piping.
 - 2. Water Distribution Fittings.
 - 3. Water Distribution Sleeve Couplings.
 - 4. Water Distribution Concrete Thrust Block
 - 5. Water Distribution Valves
- B. Related Requirements:
 - 1. Section 312000 – Earth Moving

1.2 REFERENCES

- A. ASTM International (ASTM):
 - 1. ASTM A307 – Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength.
 - 2. ASTM A536 – Specification for Ductile Iron Castings.
 - 3. ASTM A5563 – Specification for Carbon Alloy Steel Nuts.
- B. American Water Works Association (AWWA):
 - 1. AWWA C104 – Cement-Mortar Lining for Ductile Iron-Pipe and Fittings.
 - 2. AWWA C110 – Ductile-Iron and Gray-Iron Fittings.
 - 3. AWWA C111 – Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
 - 4. AWWA C116 – Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
 - 5. AWWA C150 – Thickness Design of Ductile-Iron Pipe.
 - 6. AWWA C151 – Ductile-Iron Pipe, Centrifugally Cast.
 - 7. AWWA C153 – Ductile-Iron Compact Fittings.
 - 8. AWWA C210 – Liquid-Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 9. AWWA C213 – Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings.
 - 10. AWWA C219 – Bolted, Sleeve-Type Couplings for Plain-End Pipe.
 - 11. AWWA C600 – Installation of Ductile Iron Water Mains and Their Appurtenances.
- C. DC Water:
 - 1. DC Water Standard Specifications.

1.3 SUBMITTALS

- A. Product Data:
 - 1. Piping.
 - 2. Sleeves.
 - 3. Valves.
- B. Information:
 - 1. Submit “Affidavits” for products stating that they comply with the requirements of this Section and the applicable AWWA standards.

2. Submit "Certifications" for each of the materials specified herein, which are used on the project, with the manufacturer's Certificate of Compliance stating that the materials meet or exceed the specified requirements.
3. Submit the "Product Data Sheets" for each product used.
4. Submit "Test" results for proof of hydraulic tests on sleeve type couplings.
5. Submit the manufacturer's "Installation Instructions and Details" for installing pipe, fittings, restrained joints, retaining glands, and sleeve type couplings.

C. Closeout:

1. Submit "Working Drawings" showing the layout and installation of the piping to be installed. Working drawings shall include but not be limited to pipe laying schedule, closure pieces, and fittings, extra mainline fittings, joint details, restraint and harnessing and special designs.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Delivery, storage, and handling shall be in accordance with AWWA C600.
- B. Coordinate delivery and distribution shall of pipe with installation and scheduled to provide minimum interference with traffic.
- C. Distribute pipe along line of work and outside trench as near as practicable to point of placement, facing in proper direction and properly wedged secure.
- D. Pipe shall not be rolled or dragged on the ground. No pipe shall be placed against trees or shrubs or in a manner that may damage private and other property.
- E. Protect pipe, pipe ends, pipe coating and lining, fittings and appurtenances from damage at all-times.
- F. Keep interior pipe surfaces clean at all times. Protect pipe ends by installing and maintaining, in good condition, approved plugs and caps.
- G. No material shall be deposited on or against pipe.

1.5 QUALITY ASSURANCE

- A. Prior to placing pipe and fittings in trench, the interior and exterior of pipe and fittings shall be inspected by Testing Agency. Pipe or fittings that are damaged shall be repaired or removed and replaced as directed by Testing Agency at no additional cost to Owner.

PART 2 - PRODUCTS

2.1 NUTS AND BOLTS

- A. Nuts shall comply with ASTM A563 unless noted otherwise in the Contract Documents.
- B. Bolts shall comply with ASTM A307 unless noted otherwise in the Contract Documents.

2.2 DUCTILE-IRON PIPE

- A. Pipe shall be ductile-iron meeting the requirements of AWWA C151 with mechanical joints.

- B. Coat exterior of pipe with shop applied coating per AWWA C151 and cement lined with double thickness and seal coated in accordance with AWWA C104.
- C. Pipe shall be furnished in lengths of 18 to 20 feet and shall include all joining materials.
- D. Pipes shall be Thickness Class 56.

2.3 FITTINGS

- A. Fittings shall be mechanical joints for ductile-iron pipe and fittings in accordance with AWWA C111.
- B. Fittings 48 inches and smaller in diameter shall be mechanical joint bell, ductile-iron in accordance with AWWA C110.
- C. Coatings for Fittings:
 - 1. Provide exterior asphaltic coating per AWWA C110 and interior cement-mortar lining per AWWA C104; or
 - 2. Provide interior and exterior fusion bonded epoxy coating, 6-8 mils in thickness, conforming to AWWA C116.
- D. All fittings shall be complete with all joint accessories, rubber gaskets, bolts and nuts.

2.4 JOINT RESTRAINT

- A. Unless otherwise noted, pressure ratings for pipe harnessing components shall not be less than the pipe working pressures of the installed pipe.
- B. Retaining glands for restraint of mechanical joint fittings to ductile-iron pipe 24 inches in diameter and smaller shall be designed to fit standard mechanical joint bells conforming to AWWA C111. Glands shall be manufactured of ductile-iron conforming to ASTM A536 with a restraining mechanism of size and arrangement per manufacturer's recommendations, of the following type:
 - 1. Ductile-iron wedges in combination with extra mainline fittings, heat-treated set screws with or without twist-off nuts, torqued per manufacturer's recommendation or hardened steel set screws with knurled and cupped points, with or without twist-off nuts.
 - 2. Megalug Series 1100 by EBAA Iron Sales, Inc., Uni-Flange Series 1400 by Ford Meter Box Co., or approved equal.
 - 3. Retainer gland shall meet working pressure ratings for installed pipe.

2.5 SLEEVE TYPE COUPLINGS

- A. Couplings shall be designed, manufactured and installed in accordance with AWWA C219 except as modified below:
 - 1. The Manufacturer shall provide an affidavit certifying compliance with the above standard.
 - 2. Couplings shall be designed for 150 psi operating pressure unless shown otherwise on the Contract Drawings. Provide manufacturer certification for proof of design tests per AWWA C219.
 - 3. The Contractor shall verify the outside diameters of the pipes to be connected, and shall select the correct diameter sleeve-type coupling to ensure a proper fit without utilizing pipe stops.
- B. The entire sleeve assembly shall be lined and coated with one of the factory-applied coating systems as follows:

1. Fusion bonded epoxy per AWWA C213 with eight (8)-12 mils minimum exterior coating thickness and eight (8)-12 mils minimum interior coating thickness.
2. Liquid epoxy per AWWA C210 with 16 mils minimum and 25 mils maximum coating thickness.
3. Other coating system as approved by the Engineer.

C. Bolts, nuts and harness tie rods shall be stainless steel as specified in AWWA C219.

D. The Contractor may use mechanical joint sleeve at no additional cost to DC Water.

2.6 FIELD APPLIED COATING AND LINING SYSTEMS

- A. Field applied coating system for repairs of pipe coatings and linings shall be a two (2) component, quick setting, 100 percent polyurethane product – Corropipe by Valspar Industrial, or equal.
- B. Lining system shall be NSF 61 compliant.
- C. Touch-up coating that is oxidized by using shop coat paint and following the manufacturer's recommendations.

2.7 GATE VALVES

- A. Adhere to the standards and specification in DC Water Specification 33 14 00 Gate Valves.

2.8 POST INDICATOR VAVLE

- A. Refer to the Contract Drawings.

2.9 FIRE DEPARTMENT CONNECTION

- A. Refer to the Contract Drawings.

PART 3 - EXECUTION

3.1 GENERAL

- A. Pipe, fittings, and specials shall be new materials.
- B. No more than 50 linear feet of pipe shall be laid in advance of backfilling.
- C. Straight pipe shall be furnished in standard uniform lengths. Approved short pipe lengths shall be used where necessary to meet line and grade or as closure pieces.

3.2 MAINTAINING WATER SERVICE

- A. Existing water service or by-pass piping shall remain in service until new water mains are complete, temporarily capped, tested, disinfected, and charged except when disconnecting or connecting new Work.

- B. Where existing pipe is cut and connected to a new pipe, Work shall be scheduled as directed by Contracting Officer Technical Representative (COTR) to minimize service interruption.
- C. The Contract shall submit a shutdown request to COTR at least five (5) days prior to cuttings or abandoning water piping.
 - 1. Prior to submitting the shutdown request all work necessary to prepare for the shutdown shall be complete, including but not limited to excavation, determining existing pipe measurements, having pipe laying sketches and work plan complete and approved, and all materials are procured and on site.
 - 2. Upon receiving the shutdown request COTR will verify the Contractor is ready to perform the connection and, if all preparatory work is complete, COTR will schedule the date of the outage and notify the Contractor of the approved outage date. Contractor shall make the connection on the date and time approved by COTR.

3.3 INSTALLATION

- A. Interior pipe surfaces shall be kept clean throughout construction by use of carefully fitted stoppers.
- B. Trench excavation and suitable bedding shall be complete to proper grade before pipe is placed. Any adjustment due to improper trench grade or settlement shall be accomplished at Contractor's expense.
- C. Pipe shall be laid to the horizontal and vertical alignment as shown on the Project Drawings. Entire length of pipe and fittings shall be bedded solidly on trench bottom to required line and grade. Under no condition shall pipe be subjected to a blow or shock to bring it to required line and grade.
- D. As part of work, bell holes shall be excavated to adequate size where necessary to accommodate proper joints.
- E. When straight pipe requires cutting, the Contractor shall take field measurements for making, closing, and connecting pieces of correct dimensions. Cutting shall leave a smooth end. The cut shall be made by abrasive saw or by a special DIP pipe cutter. All pipe ends shall be square with the longitudinal axis of the pipe and shall be reamed and smoothed to assure a good connection.

3.4 MAKING CONNECTIONS

- A. Unless otherwise indicated, the Contractor shall cut existing water mains and remove pipe, fittings, and appurtenances to connect new water mains, reconnect existing water mains, and perform all work necessary or incidental thereto.
- B. Transferring water connections, completing connections, and abandoning pipe shall be performed continuously until complete. The Contractor shall provide necessary labor, equipment, and materials, including but not limited to overtime pay, lights, and generators, to complete the work on a 24 hour basis at no additional cost to Owner.

3.5 JOINTS AND FITTINGS

- A. Joints shall be assembled per AWWA C600 and manufacturer's recommendations.

- B. Springing of joints is prohibited.
- C. Unless otherwise specified, the diameter of ductile-iron plain ends shall be the same as for mechanical-joint cast or ductile-iron pipe.
- D. The inside of the pipe socket and the outside of the plain end shall be thoroughly cleaned to remove oil, grit, excess coating and other foreign matter.
- E. A retainer gland shall not be used on any pipe joint connecting ductile-iron pipe to existing cast-iron pipe.
- F. Pipe installation of proprietary restrained joint pipe systems shall be in accordance with the manufacturer's printed recommendations.
- G. Pipe Deflections:
 - 1. Under no circumstances shall pipe deflections, either horizontal or vertical, exceed the manufacturer's printed recommendations. Where deflections will exceed the manufacturer's recommendations, fittings shall be used.
 - 2. Keep the pipe straight while pushing the pipe home. The joint deflections shall only be completed after the pipe is homed.
 - 3. Changes in alignment or grade greater than the manufacturer's allowable deflection shall be made using fittings.
- H. Installing Mechanical Joint Fittings:
 - 1. Install mechanical joint fittings in accordance with the fitting manufacturer's instructions and AWWA C600.
 - 2. Torque range for retainer gland set screws shall be in accordance with fitting manufacturer's recommendations or AWWA C600 if manufacturer does not make recommendations.
 - 3. T-bolts, harness tie rods, coupling bolts, flanged joint bolts, etc. shall be installed to provide at least one complete thread projecting beyond the nut when properly tightened.
 - 4. If effective seal is not obtained at maximum specified torque, the joint shall be disassembled, cleaned and reassembled at no additional cost to the Owner.
 - 5. Bolts that are overstressing shall be removed and replaced at no additional cost to the Owner.
- I. After each ductile-iron pipe, fitting, and valve is jointed, each joint area including restraint elements shall be cleaned, inspected and approved before next section is installed.
- J. Carbon steel bolts, clamps, and connecting parts including thread areas, etc., shall receive one prime coat and one finish coat of field-applied coating system applied in accordance with AWWA C210. Field coatings shall be complete prior to line tests.

3.6 SLEEVE TYPE COUPLINGS

- A. General:
 - 1. Use sleeve-type couplings only when indicated on the Contract Drawings.
- B. Pipe end condition:
 - 1. Pipe for use with sleeve type couplings shall have plain ends, cast or machined at right angles to pipe axis.
 - 2. Ductile-iron and cast-iron pipe shall be smooth and round for a distance of eight inches from end of the pipe up through 24 inch diameter, and for 12 inches from the end of the pipe for pipe larger than 24 inch diameter.

3. Maximum actual O.D. of pipe end shall be such as to permit the passing of a ring gauge having an internal bore not greater than 0.01 inch larger than the nominal O.D. plus the maximum variation indicated in AWWA C110.
4. Steel pipe larger than 10-3/4 inches O.D. shall be free from indentations, projections or roll marks for a distance of eight inches from the end of the pipe and, within this distance, the actual O.D. shall be not more than 1/32 inch smaller than nominal O.D. Maximum actual O.D. shall be not more than 1/32 inch smaller than nominal O.D. Maximum actual O.D. of pipe end shall be such as to permit the passing of a ring gauge having an internal bore not greater than 3/32 inch larger than pipe nominal O.D.
5. For each type pipe, minimum actual O.D. shall be determined by use of a steel tape, calibrated to 100th of an inch, applied circumferentially to pipe.

C. Assembly:

1. Couplings shall be assembled in accordance with the manufacturer's printed installation instructions and provide a leak free connection when the pipe is tested at required test pressure.
2. Laying deflection per coupling shall not exceed manufacturer's recommendations.
3. Harness all couplings using stainless steel tie rods.
4. The Contractor may use mechanical joint sleeve at no additional cost to Owner.

3.7 BLOW-OFFS

- A. Piping for air and drain blow-offs shall be included as part of the water utility piping installation.
- B. Blow-off valves and casings shall be supplied as specified in DC Water Specification 33 06 23 Concrete Valve Casings and DC Water Specification 33 14 00 Gate Valves.

3.8 THURST RESTRAINT

- A. Pipe shall be restrained at all joints, fitting, valves, appurtenances, and specials using the joint restraining systems specified in this Section.
- B. Concrete thrust restraints shall be used when shown on the Contract Drawings, as required by DC Water Specification 33 11 20 Concrete Thrust Restraints or when approved by Engineer and shall be in accordance with DC Water Specification 33 11 20.
- C. Mechanical joint and retainer glands shall be used to restrain fittings. Restraint of mechanical joint ductile-iron pipe shall be accomplished by using approved ductile-iron retainer glands in lieu of follower glands, installed in accordance with manufacturer's printed instructions.
- D. After each restrained joint is complete, the joint restraint elements shall be cleaned and inspected.

3.9 DISINFECTING WATER PIPING

- A. Piping for water systems shall be disinfected in accordance with DC Water Specification 33 13 01 Disinfecting Water Mains.

3.10 PRESSURE AND LEAKAGE TESTING

- A. Pressure pipe shall be tested in accordance with DC Water Specification 33 19 05 Pressure and Leakage Testing – Pressure Pipe.

3.11 EXTRA MAINLINE FITTINGS

- A. Contractor shall identify to Engineer extra mainline fittings necessary for closure sections or unanticipated interferences. If Engineer agrees that extra mainline fittings are necessary, the Contractor shall:
1. Verify the size of existing pipe in service and provide fittings in accordance with this section to complete a closure or navigate around an unanticipated interference.
 2. Contractor shall provide working drawings showing the proposed modifications to the design and the limits of pipe and fittings that will be needed for closure or navigating around the unanticipated interference.
 3. Upon review and approval of the proposed modifications by Engineer, the Contractor shall install the modifications as shown on the working drawings.

END OF SECTION

FOR REFERENCE ONLY

SECTION 33 4200 – STORMWATER CONVEYANCE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Storm Conveyance Piping.
 - 2. Storm Conveyance Fittings.
 - 3. Storm Conveyance Manholes.
 - 4. Storm Conveyance Overflow Structures.
 - 5. Storm Conveyance Trench Drains.
 - 6. Storm Conveyance Drain Basins.
- B. Related Requirements:
 - 1. Section 312000 – Earth Moving

1.2 REFERENCES

- A. ASTM International (ASTM):
 - 1. ASTM A48 – Standard Specification for Gray Iron Castings
 - 2. ASTM A536 – Standard Specification for Ductile Iron Castings
 - 3. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
 - 4. ASTM B26 – Standard Specification for Aluminum-Alloy Sand Castings
 - 5. ASTM C1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
 - 6. ASTM C139 – Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes
 - 7. ASTM C231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 - 8. ASTM C270 – Standard Specification for Mortar for Unit Masonry
 - 9. ASTM C32 – Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale)
 - 10. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
 - 11. ASTM C478 – Standard Specification for Precast Reinforced Concrete Manhole Sections
 - 12. ASTM C507 – Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
 - 13. ASTM C55 – Standard Specification for Concrete Building Brick
 - 14. ASTM C923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
 - 15. ASTM C990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
 - 16. ASTM D1751 – Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
 - 17. ASTM D1752 – Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion
 - 18. ASTM D1784 – Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
 - 19. ASTM D1785 – Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
 - 20. ASTM D2167 – Density and Unit Weight of Soil in Place by the Rubber Ballon Method

21. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
22. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
23. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
24. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

B. DC Water:

1. DC Water Standard Specifications.

1.3 SUBMITTALS

A. Product Data:

1. Storm drainage piping and fittings.
2. Manholes.
3. Overflow Structures.
4. Drain Basins.
5. Stormwater Trench Drains

B. Shop Drawings:

1. Manholes, Overflow Structures, and Drain Basins:
 - a. Indicate RIM and Bottom Elevations
 - b. Indicate the size of all incoming pipes and the outgoing pipe.
 - c. Indicate the invert elevations for all incoming pipes and the outgoing pipe.
 - d. Indicate the location of any throat openings, if required in the Drawings.
2. Stormwater Trench Drain:
 - a. Indicate critical dimensions, installation and anchoring requirements, and other details.
 - b. Signed and sealed by the qualified professional engineer responsible for their preparation.

C. Information:

1. Source Quality-Control Reports: For Stormwater Trench Drains.
2. Field Quality-Control Reports: For storm drainage pipe, manholes, overflow structures, drain basins, and Stormwater Trench Drains.
3. Qualifications Statement: For manufacturer.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: Accept materials on Site in manufacturer's original packaging and inspect for damage.
- B. Store materials according to manufacturer instructions.
- C. Protection:
1. Protect materials from moisture and dust by storing in clean, dry location remote from construction operations areas.
 2. Provide additional protection according to manufacturer instructions.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.6 WARRANTY

- A. Furnish five year manufacturer's warranty for stormwater trench drains.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Perform Work according to:
1. DC Water Standards and Specifications

2.2 STORM DRAINAGE PIPING

- A. Reinforced Concrete Piping:
1. Pipe:
 - a. Comply with ASTM C76, Class IV, Wall Type B.
 - b. Reinforcement: Bars complying with ASTM A615, Grade 60
 - c. Inside Nominal Diameter: According to the Drawings
 - d. End Connections: Bell and spigot
 2. Fittings: Concrete.
 3. Joints:
 - a. Comply with ASTM C443.
 - b. Gaskets: Rubber, compression.
- B. PVC Piping:
1. Pipe:
 - a. Comply with ASTM D1785, Schedule 80.
 - b. Inside Nominal Diameter: According to the Drawings
 - c. Style: Bell and spigot with rubber-ring seal gasket joint.
 2. Fittings: PVC.
 3. Joints:
 - a. Comply with ASTM F477.
 - b. Gaskets: Elastomeric.

2.3 MANHOLES

- A. In accordance with the latest editions of DC Water Standards and Specifications, unless otherwise noted on the plans. Conform to ASTM C478. Joints between precast concrete risers and tops shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure or made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS.

2.4 OVERFLOW STRUCTURES

- A. All overflow structures' materials and methods of installation shall be in conformance with the latest edition of DC Water Standards and Specifications unless otherwise noted on the plans.

2.5 MANHOLE AND OVERFLOW STRUCTURE FRAMES AND COVERS

- A. In accordance with the latest editions of DC Water Standards and Specifications, unless otherwise noted on the plans. Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be cast gray iron, ASTM A48, Class 35B;

cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26, Alloy 356.O-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.6 MISCELLANEOUS MATERIALS

A. Concrete:

1. Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 3,500 psi concrete under Section 03 30 00 CAST IN PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 1-1/2 inches. Air content shall be determined in accordance with ASTM C231/C231M. The concrete covering over steel reinforcing shall not be less than 1 inch thick for covers and not less than 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

B. Mortar:

1. Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar but in no case shall exceed 6 gallons of water per sack of cement. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

C. Precast Concrete Segmental Blocks:

1. Precast concrete segmental block shall conform to ASTM C139, not more than 8 inches thick, not less than 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

D. Brick:

1. Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 1/2 inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.7 JOINTS

A. Flexible Watertight Joints:

1. Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 54 inches.

2. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer Technical Representative (COTR) before gaskets or jointing materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

B. External Sealing Bands:

1. Requirements for external sealing bands shall conform to ASTM C877.

C. Flexible Watertight, Gasketed Joints:

1. Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 7 inches wide and approximately 3/8 inch thick, meeting the requirements of ASTM D1056, Type 2 A1, and shall have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171. Rubber O-ring gaskets shall be 13/16 inch in diameter for pipe diameters of 36 inches or smaller and 7/8 inch in diameter for larger pipe having 1/2 inch deep end corrugation. Rubber O-ring gaskets shall be 1-3/8 inches in diameter for pipe having 1 inch deep end corrugations. O-rings shall meet the requirements of ASTM C990 or ASTM C443. Preformed flexible joint sealants shall conform to ASTM C990, Type B.
2. Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

2.8 STRUCTURE STEPS

- A. Storm structures with a depth of 4 feet and greater must be provided with manhole steps. Unless stated otherwise on plans, steps must be a minimum of 10 inches wide with a maximum step spacing of 16 inches on center. Step must be embedded a minimum of 3 inches into concrete structure wall and extend a minimum of 4 1/2 inches from the face of structure wall. Step shall withstand a minimum force of 300 pounds. The preferred structure step is constructed of #4, grade 60 reinforcing bar encased with polypropylene.

2.9 RESILIENT CONNECTORS

- A. Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923.

2.10 TRENCH DRAINS

A. Performance and Design Criteria:

1. Loading: H-20, according to AASHTO HB-17.

B. Channel Drains:

1. Material, built-in slope, bottom radius, channel section length, end connections, and bottom outlet according to manufacturer requirements.
2. Width: According to the Drawings.

C. Channel Grates:

1. Material, openings, style, and color according to Landscape Drawings and/or Exhibit Drawings.
2. Shall be high heel proof.

D. Accessories:

1. Grate lock.
2. End cap and screws.
3. End outlet.
4. Bottom outlet adapter.

2.11 DRAIN BASINS**A. Basin**

1. Shall be manufactured from PVC pipe stock, utilizing a thermoforming process to reform the pipe stock to the specified configuration.
2. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with specified pipe system.
3. Joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477.
4. The pipe bell spigot shall be jointed to the main body of the drain basin or catch basin. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.

B. Grates and Frames

1. Furnished for all surface drainage inlets, shall be ductile iron, and shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet.
2. Grates for drain basins shall be capable of supporting various wheel loads as specified.
3. Ductile iron used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05. Grates and covers shall be provided and painted black.

PART 3 - EXECUTION**3.1 INSTALLATION OF PIPING**

- A. Excavation of trenches, and for appurtenances and backfilling for piping, manholes, and overflow structures shall be in accordance with the applicable portions of these Specifications, DC Water Standards and Specifications, and the requirements specified below.

B. Trenching:

1. The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 24 inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheet piling and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

C. Removal of Rock:

1. Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 8 inches or 1/2 inch for each foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 20 00 Earth Moving.

D. Removal of Unstable Material:

1. Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the COTR, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Government.

E. Bedding:

1. Follow the requirements noted in the Drawings and according DC Water Standards and Specifications.

F. Placing Pipe:

1. Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed 5%. Lay bell and spigot pipe shall proceed upgrade with the bell end upstream.

3.2 JOINTS**A. Flexible Watertight Joints**

1. Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.3 DRAINAGE STRUCTURES**A. Manholes and Overflow Structures:**

1. Construction shall be of reinforced concrete, precast reinforced concrete; complete with frames and covers or gratings; and with fixed galvanized manhole steps as necessary. Pipe connections to concrete manholes and inlets shall be made with flexible, watertight connectors.

B. Structure Step Installation:

1. Step shall be vertically aligned and uniformly spaced the entire depth of any structure. In precast structures the steps may be cast in place, mortared into holes provided by fabricator or driven.

3.4 BACKFILLING

A. Backfilling Pipe in Trenches

1. After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 8 inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the COTR, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

B. Backfilling Pipe in Fill Sections

1. For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 6 inches in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12 inches above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12 inches above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 8 inches. Use select granular material for this entire region of backfill for flexible pipe installations.

3.5 MOVEMENT OF CONSTRUCTION MACHINERY

- A. When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a pipe or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.6 COMPACTION

A. General Requirements:

1. Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

B. Minimum Density:

1. Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

- a. Under paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
- b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.
- c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7 TRENCH DRAINS

A. Examination:

1. Examine substrates, areas, and conditions for compliance with the requirements for installation tolerances and other conditions affecting performance.
2. Verify that excavation is ready to receive stormwater trench drains.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation:

1. Do not install stormwater trench drains if Site conditions induce loads exceeding structural capacity of trench drains.

C. Installation of Stormwater Trench Drains:

1. Excavation:
 - a. According to manufacturer requirements and to depth as indicated on Drawings.
 - b. Provide clearance around sidewalls of structure for construction operations.
 - c. If groundwater is encountered, prevent accumulation of water in excavations; place stormwater trench drains in dry trench.
2. Place stormwater trench drain sections plumb and level, to elevations as indicated on Drawings, and according to manufacturer's instructions.
3. Backfilling: As specified by manufacturer and in Section 31 20 00 Earth Moving.
4. Cut and fit for pipe.

3.8 DRAIN BASINS

- A. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or 2 material as defined in ASTM D2321. The surface drainage inlets shall be bedded and back-filled uniformly in accordance with ASTM D2321. The drain basin body shall be cut at the time of the final grade so as to maintain a one piece, leak proof structure. No brick, stone or concrete block will be used to set the grate to the final grade height. For H-25 load rate installations, an 8-inch to 10-inch thick concrete ring shall be poured under the grate and frame as recommended by details provided from the manufacturer.

3.9 FIELD QUALITY CONTROL

- A. Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.
- B. Hydrostatic Test on Watertight Joints: Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber

gaskets shall comply with the oil resistant gasket requirements of ASTM C443. Certified copies of test results shall be delivered to the COTR before gaskets or jointing materials are installed.

1. PVC Pipe: A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Test requirements for joints in PVC, PE, and PP plastic pipe shall conform to ASTM D3212.
2. Leakage Test: Lines shall be tested for leakage by water testing or exfiltration tests, as appropriate, prior to completing backfill. Testing of individual joints for leakage by water shall conform to ASTM C1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the COTR. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 2 feet is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 0.2 gallons per inch in diameter per 100 feet of pipeline per hour.
3. Determination of Density: Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the COTR. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.
4. Deflection Testing: Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a laser profiler or to determine if allowable deflection has been exceeded.
5. Laser Profiler: Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment for pipe sizes 48 inches or less. Use a camera with suitable lighting to allow a clear picture of the entire periphery of the pipe interior. Center the camera in the pipe both vertically and horizontally. The camera must be able to pan and tilt to a 90 degree angle with the axis of the pipe rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition. The video image shall be clear, focused, and relatively free from roll static or other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe. For initial post installation inspections for pipe sizes larger than 48 inches, a visual inspection shall be completed of the pipe interior.

3.10 INSPECTION

- A. Post-Installation Protection: Visually inspect each segment of concrete pipe for alignment, settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.
1. Flexible Pipe: Check each flexible pipe (PVC) for rips, tears, joint separations, soil migration through the joint, cracks, localized buckling, bulges, settlement and alignment.
 2. Post-Installation Inspection Report: The deflection results and final post installation inspection report must include: a copy of all video taken, pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).
- B. Trench Drains:
1. Inspect stormwater trench drains immediately prior to placement in excavation to verify that trench drains are internally clean and free from damage.
 2. Remove and replace damaged sections.
 3. Verify alignment of gate and components.
 4. Verify that gate operates smoothly and does not bind or scrape.
 5. Prepare test and inspection reports.
- C. Repair of Defects:
1. Leakage Test: When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.
 2. Deflection Testing: When deflection readings are in excess of the allowable deflection of average inside diameter of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.
 3. Inspection: Replace pipe or repair defects indicated in the Post-Installation Inspection Report.
 - a. Flexible Pipe: Replace pipes having cracks or splits.
 4. Protection: Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.
 5. Warranty Period: Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

END OF SECTION