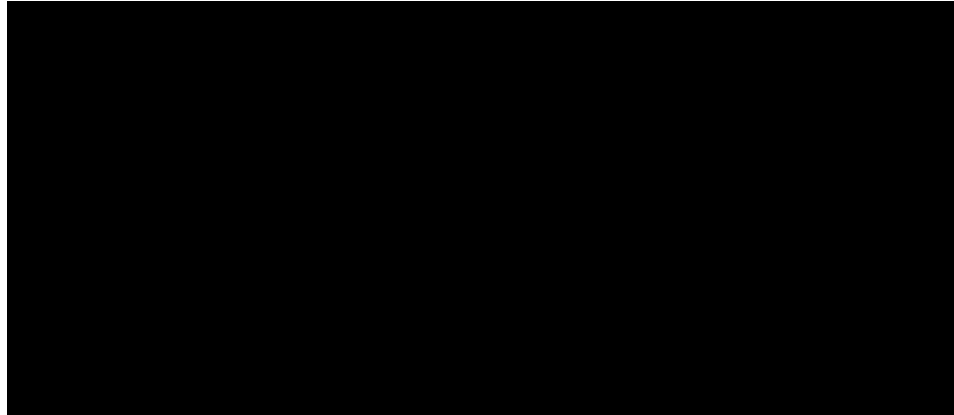


Dyess AFB

Electrical Distribution System Engineering Evaluation

[REDACTED]



Volume 1 – Power System Evaluation

Report: CLIN01 Dyess AFB

Final Report – April 2025

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EXECUTIVE SUMMARY

Purpose

This project studies the Dyess AFB electrical system. The purpose of this project is to perform an electrical analysis of the primary electrical distribution system through the secondary up to and including the building service entrance disconnect and includes motor loads 50 Hp or greater. Specifically, the electrical distribution system is inclusive of:

- Switching stations
- Substations
- Distribution, and service cables
- Primary distribution equipment
- Government owned power generating stations feeding directly into the primary distribution system.
- Government owned renewable power generation feeding directly into the primary distribution system.

The project activities consist of three distinct phases:

1. Phase 1: Conduct field surveys and testing to support a detailed “as-built” of the existing primary electrical distribution system.
2. Phase 2: Perform an electrical power system analysis of the existing primary distribution system, including power flow, short circuit, and electrical protection/coordination. The electrical analyses are performed using EasyPower® electrical analysis software. The study serves to baseline performance of the existing system in support of a detailed engineering evaluation of the primary distribution system.
3. Phase 3: Conduct a detailed engineering evaluation of the primary electrical system to establish future modifications, expansions, and upgrades to support future electrical requirements and improve system efficiency, reliability, and maintainability.

Project Deliverables

The following deliverables are provided in support of this power system study:

- Analysis report summarizing project findings and results.
- Field walkdown data files – on DVD.
- EasyPower electrical model for the primary distribution system.
- Electronic copies of photographs taken of electrical equipment during field walkdowns – on DVDs.
- Oil sampling and testing reports of Substation transformers.
- Thermal imaging reports of the same Substation transformers.
- EasyPower software and associated training.
- Laptop computer capable of running the provided EasyPower software.
- Updated electrical distribution system single-line drawings.
- New electrical layout drawings.
- Arc Flash Hazard Labels.
- Equipment identification Labels, as identified.
- Equipment Geospatial Data (ArcGIS model).

Site Specific Analysis Assumptions

1. The EASYPOWER model was developed based on field observations/measurements, photo documentation, single-line drawings, and other data provided by the client.
2. TWN performed a site visit for verification and/or collection of field data.
3. The latest available utility impedance information from American Electric Power Texas (AEP Texas) was used to determine utility available fault current data.
4. The “Normal Operating Configuration” of the facility is based on client-provided information, discussions with facility personnel, and field observations. See electrical single-line for current operating configuration.
5. Transformers are modeled center tapped if no alternate data was available on tap settings. Note some transformer taps are located on the top of distribution type transformers.
6. Switches and breakers are in their normal operating configurations.

7. Relevant Information for data sheets and other client-provided information is provided in electronic format only and is located on the DVD.
8. Where upstream devices will not clear an arcing fault within 2 seconds the incident energy calculations are based on a maximum of 2 seconds. This is based on the assumption that anyone inside the arc flash boundary will vacate the boundary within 2 seconds. However, careful consideration must be taken if the 2 seconds clearing time is used in situations where the arcing fault could be in a confined space like a manhole or when someone is working from a bucket truck.
9. In instances where the instantaneous setting cannot be verified in the field, the setting shall be configured to its maximum (High) value.
10. Capacitors are assumed in-service unless normal operating conditions have them switched out.
11. Spot load meter readings are used as a basis for the load flow study.
12. Unlabeled equipment found in the field was designated, and associated with, the locations closest facility based on the client provided map.
13. Switchboards and/or Panelboards without a proper Panel Schedule: the installation personnel (local authority) determine loads and/or sources.
14. If a feeder breaker(s) was not labeled, it was assumed the installation used like feeder breakers and were modeled accordingly, inclusive of adjustments for as-found conditions and legible information.
15. Load distances were assumed to be 50' for Panelboards within buildings (beyond the service disconnect).
16. Breakers not available in the EasyPower Library were requested as additions to the model. Where EasyPower was unable to incorporate a specific breaker, a similar breaker was used with ratings and settings adjusted to match as-found conditions.
17. Cable sizes were assumed where determination was not possible either by field verification or one-line diagram.
18. Cable derating associated with duct banks has been considered based on field observation. Where configuration of duct bank was uncertain, duct bank configuration was assumed based on paralleled cables to serve this load.
19. Load data was measured at distribution transformer secondaries. Load was then manually distributed amongst the facilities fed by each distribution transformer.

Table 1 – Dyess AFB Assumptions

Devices	Total Count	#Assumptions	%	Comments
Cables	1267	33	2.60%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the cables, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Transformer	496	110	22.18%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for various transformers, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
LV Breaker	295	49	16.61%	Due to safety considerations associated with energized panels and removal of covers while energized, access to covered name plate data for the LV breakers was in-accessible. Under this condition, engineering estimates based on similar conditions, prior studies and existing conditions were made. Specifically related to name plate and/or trip setting.
CTs	48	1	2.08%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the CTs, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Motors	24	7	29.17%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the motor, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Fuses	1132	23	2.03%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the fuse, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Switches	187	2	1.07%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the switch, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Sectionalizer / Junction Box	123	1	0.81%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the Sectionalizer/Junction Box, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.

Power Flow Study

One (1) EasyPower model was developed using Utility as the source. The following summarizes the power flow results:

- There are three (3) cables overloaded.
- There is one (1) transformer within the 10% overload threshold (T9121B).
- There are multiple locations where calculated voltage variation exceeds 3%. See Section 4.4.4 for specific locations. See Table 4-2 for voltage variations that exceed 3%.
- There are 64 locations where the power factor is less than 90%. See Section 4.4.4 for specific locations.
- There are 24 motors over 50 HP. See Section 4.4.5 for more information.
- The current estimated peak demand is within the capability of the system.

Cross-Connect Capability

Cross-connect capabilities at Dyess AFB are:

C.C. #1: Dyess AFB's 12.47 kV Pole "P-A2-1A" Ties FDR A1 and FDR A2 through Switch S+C#11.

C.C. #2: Dyess AFB's 12.47 kV Pole "P-B4-108A" Ties FDR A1 and FDR B4 through Switch S+C#14.

C.C. #3: Dyess AFB's 12.47 kV Pole "P-C1-10A" Ties FDR A2 and FDR C1 through Switch S+C#13.

C.C. #4: Dyess AFB's 12.47 kV Pole "P-B2-3" Ties FDR B1 and FDR B2 through Fused Switch P-B2-3.

C.C. #5: Dyess AFB's 12.47 kV Pole "P-B2-L1-7" Ties FDR B1 and FDR B2 through Switch P-B2-L1-7.

C.C. #6: Dyess AFB's 12.47 kV Pole "P-B1-32" Ties FDR B1 and FDR B2 through Fused Switch P-B1-32.

C.C. #7: Dyess AFB's 12.47 kV Pole "P-B2-L2-5" Ties FDR B1 and FDR B2 through Switch P-B2-L2-5.

C.C. #8: Dyess AFB's 12.47 kV Pole "P-B1-42A" Ties FDR B1 and FDR C4 through Switch S+C#1.

C.C. #9: Dyess AFB's 12.47 kV Pole "P-B3-L1-8" Ties FDR B2 and FDR B3 through Fused Switch P-B3-L1-8.

- C.C. #10: Dyess AFB's 12.47 kV Pole "P-B2-L3-4" Ties FDR B2 and FDR C2 through Switch P-B2-L3-4.
- C.C. #11: Dyess AFB's 12.47 kV Pole "P-C4-51" Ties FDR B2 and FDR C4 through Fused Switch P-C4-51.
- C.C. #12: Dyess AFB's 12.47 kV Pole "P-C4-L10-3" Ties FDR B2 and FDR C4 through Fused Switch P-C4-L10-3.
- C.C. #13: Dyess AFB's 12.47 kV Pole "P-B2-53" Ties FDR B2 and FDR C4 through Fused Switch P-B2-53.
- C.C. #14: Dyess AFB's 12.47 kV Pole "P-B2-64" Ties FDR B2 and FDR C3 through Switch S+C#3.
- C.C. #15: Dyess AFB's 12.47 kV Pole "P-B2-67" Ties FDR B2 and FDR C4 through Switch P-B2-67.
- C.C. #16: Dyess AFB's 12.47 kV Pole "P-B4-L1-8" Ties FDR B3 and FDR B4 through Fused Switch P-B4-L1-8.
- C.C. #17: Dyess AFB's 12.47 kV Pole "P-B3-26A" Ties FDR B3 and FDR C2 through Switch S+C#2.
- C.C. #18: Dyess AFB's 12.47 kV Pad Mount Switch "SB3-015" Ties FDR B3 and FDR C2 through Switch SB3-015-T2.
- C.C. #19: Dyess AFB's 12.47 kV Pole "P-C2-L1-24" Ties FDR B4 and FDR C2 through Switch C2-L1-24.
- C.C. #20: Dyess AFB's 12.47 kV Pole "P-C4-26" Ties FDR C3 and FDR C4 through Fused Switch P-C4-26.
- C.C. #21: Dyess AFB's 12.47 kV Pole "P-C4-30" Ties FDR C3 and FDR C4 through Fused Switch P-C4-30.
- C.C. #22: Dyess AFB's 12.47 kV Pole "P-C4-L4-7" Ties FDR C4 and FDR C5 through Switch S+C#6.
- C.C. #23: Dyess AFB's 12.47 kV Pole "P-C5-21" Ties FDR C4 and FDR C5 through Fused Switch P-C5-21.

Short Circuit Study

The 69kV Utility lines provide the main source of short circuit currents available throughout the system. Refer to Table 2 for a summary of the available short circuit current. These Available Short Circuit Current values have been used as the basis for the EasyPower short circuit study.

Table 2 – Dyess AFB Main Substation Available Short Circuit Current

Utility	Short Circuit Type	Voltage Reference	Fault Current
AEP Texas Alpha 69kV Line	Three Phase	69 kV	982.1 MVA
	Single line to ground	69 kV	727.1 MVA
AEP Texas Bravo 69kV Line	Three Phase	69 kV	973.7 MVA
	Single line to ground	69 kV	757.9 MVA
AEP Texas Charlie 69kV Line	Three Phase	69 kV	808.9 MVA
	Single line to ground	69 kV	574.6 MVA

Base Case – Utility and Generator Service:

- American Electric Power Texas (AEP) provides the main source for fault current at Dyess AFB via the three (3) 69kV Lines that feed into Substations “Alpha”, “Bravo”, and “Charlie”.
- All feeders operate normally as shown in the associated electrical drawings.

The system contains forty-five (45) locations with possible Warnings and Violations. Table 3 provides the location for the areas requiring corrective action. Short circuit tables are provided in Section 6.3.

Table 3
Base Case – Utility - Short Circuit Violations and Warnings

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
B95S1-1 IN	GE	SCP	14.42	44.2%	VIOLATION	14.42	44.2%	VIOLATION
B95S1-2 IN	GE	SCP	16.85	68.5%	VIOLATION	16.85	68.5%	VIOLATION
B95S1-3 IN	GE	SCP	14.26	42.6%	VIOLATION	14.26	42.6%	VIOLATION
B95S2-2 IN	GE	SCP	15.46	54.6%	VIOLATION	15.46	54.6%	VIOLATION

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
B95S2-3 IN	GE	SCP	14.21	42.1%	VIOLATION	14.21	42.1%	VIOLATION
B95S2-4 IN	GE	SCP	14.14	41.4%	VIOLATION	14.14	41.4%	VIOLATION
B95S2-5 IN	GE	SCP	14.08	40.8%	VIOLATION	14.08	40.8%	VIOLATION
B95S2-6 IN	GE	SCP	11.37	13.7%	VIOLATION	11.37	13.7%	VIOLATION
LVB-B4201 (MAIN)	GE	TQD	13.36	33.6%	VIOLATION	13.36	33.6%	VIOLATION
B4201 (B) OUT	GE	Q	13.36	33.6%	VIOLATION	13.36	33.6%	VIOLATION
B4218 SE2 (MLO)	SQD		11.64	16.4%	VIOLATION	N/A	N/A	N/A
B5015 (MDP MLO)	GE	QMR	12.32	23.2%	VIOLATION	9.19	-8.1%	Warning
B5130 OUT	SQD		11.06	10.6%	VIOLATION	N/A	N/A	N/A
B5280 OUT	SQD		11.13	11.3%	VIOLATION	N/A	N/A	N/A
B6137 SE2	BUSS	NON(H) 100-600A	12.02	20.2%	VIOLATION	N/A	N/A	N/A
LVB-B7106B SE2	Siemens	QP 2P	18.08	80.8%	VIOLATION	18.08	80.8%	VIOLATION
B7106B SE2 IN	GE		18.08	80.8%	VIOLATION	18.08	80.8%	VIOLATION
B7206 (PANEL M) SE1 OUT	SQD	HCN	15.28	9.1%	VIOLATION	N/A	N/A	N/A
B7206 SE2	Siemens	QP 2P	14.72	47.2%	VIOLATION	14.72	47.2%	VIOLATION
B7206 IN	GE	TLM	14.48	44.8%	VIOLATION	14.48	44.8%	VIOLATION
FDSC-B7216	BUSS	NON(H) 100-600A	13.71	37.1%	VIOLATION	10.46	4.6%	VIOLATION
B7216 IN	SQD	Safety Switch	12.59	25.9%	VIOLATION	9.98	-0.2%	Warning
LVB-B7416	SQD	QB	12.83	28.3%	VIOLATION	12.83	28.3%	VIOLATION
B7416 (PANEL A) IN	SQD		12.83	28.3%	VIOLATION	12.83	28.3%	VIOLATION
B8006 SE2 OUT	SQD		13.43	34.3%	VIOLATION	N/A	N/A	N/A
LVB-B8011 SE1	SQD	QB	17.67	76.7%	VIOLATION	N/A	N/A	N/A

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
B8011 SE1 IN			17.67	76.7%	VIOLATION	N/A	N/A	N/A
LVB-B8080A	GE	THQL	11.20	12.0%	VIOLATION	N/A	N/A	N/A
B8080A IN	GE		11.20	12.0%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE1 (MAIN)	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE1 (PNL A) IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE2 (MAIN)	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE2 (PNL B) IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE3	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE3 IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE4 (MLO)	Buss		15.08	50.8%	VIOLATION	9.20	-8.0%	Warning
B11955B (MLO)	SQD		9.18	-8.2%	Warning	N/A	N/A	N/A
BP4218 SE1 OUT			9.10	-9.0%	Warning	N/A	N/A	N/A
B-BOMBPAD OUT			9.33	-6.7%	Warning	N/A	N/A	N/A
LVB-B-RAMP4	SQD	QOM 2	9.91	-0.9%	Warning	9.91	-0.9%	Warning
B-RAMP4 IN	SQD	QOM	9.91	-0.9%	Warning	9.91	-0.9%	Warning
LVB-B4202 (MISSION ESSEN.)	GE	TQD	9.83	-1.7%	Warning	N/A	N/A	N/A
B5020 IN	EATON		13.43	-4.0%	Warning	14.52	3.7%	VIOLATION
LVB-B7233 SE1B	Cutler Hammer	BAB	9.17	-8.3%	Warning	N/A	N/A	N/A
B7233 (7-05) SE1B IN	Westinghouse	PRL1	9.17	-8.3%	Warning	N/A	N/A	N/A

Note: Short circuit violations are any device where the available fault current is higher than the Short Circuit rating of the device (i.e., overduty). A warning would be any device that is within 10% of being overdutied. Recommendations for replacements are included in the budget at the end of Section 11.

The study performed is a primary distribution study and is not intended to model the interior electrical system of the Installation. The service entrance breakers were inspected and included in the model. In some instances, the breaker interrupting rating could not be determined by a visual

examination of the exposed breaker parts. In these cases, engineering assumptions were made. In the future, it is recommended that the breaker interrupting rating be verified whenever performing work on interior panels and switchgear.

Arc Flash Results

An arc flash summary is provided in Volume 2 Appendix L for the primary distribution system for the existing protective device settings throughout the system.

The arc flash hazard incident energy distribution for the Base is shown in Figure 1 below. Section 7.7.1 provides a detailed list of locations where incident energy is above 12 cal/cm² for medium/high voltage and above 40 cal/cm² for low voltage. Section 9.2 provides a summary of adjustments for coordination and Arc Flash Hazard incident energy reduction.

Incident Energy Summary for use with NFPA-70E Table H.3(b) for Guidance on Selection of Arc Rated Clothing and Other P.P.E.	Quantity
Less than or Equal to 1.2 cal/cm ²	1638
Greater than 1.2 cal/cm ² to 12 cal/cm ²	693
Greater than 12 cal/cm ² to 40 cal/cm ²	246
Do not work on Energized Equipment (TX secondary Terminal greater than 40 cal/cm ²)	<u>37</u>
Do not work on Energized Equipment (Accessible equipment greater than 40 cal/cm ²)	<u>36</u>

Figure 1
Arc Flash Results Utility Source System (As Found)

The potential for upgrading the existing protective devices that provide an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)) is being considered. These devices can be used to improve the safe operation and work in and around high arc flash incident energy devices.

Future consideration should be given to establishing an acceptable Arc Flash incident energy level at the facility. This would be applied to new designs as well as re-designs to lower the incident energy levels shown in the above tables. Based on an Arc Flash Risk level philosophy, an in-depth Arc Flash Mitigation engineering design could then be performed for adoption of an incident energy philosophy.

Coordination Study

The following protective coordination issues have been identified:

- Recommendations were made to improve coordination and reduce Arc Flash Incident Energy throughout the system.
 - See Section 9 for more details and associated setting changes (Recommendations).
 - See Section 11 for specific system recommendations.

Harmonic Distortion Results

Based on IEEE 519, the voltage and current harmonic limits are evaluated. Utilizing these analysis methods, the total harmonic distortion and the individual harmonics are calculated.

Voltage harmonic distortion was less than 3% percent within the system. There were no locations where Voltage Harmonic Distortion was found to be greater than 5%.

Current harmonic distortion reached 100% in seven (7) locations within the system. Current harmonic distortion varies considerably.

Note: Harmonic distortion data is collected via instantaneous spot measurements at the secondary transformer level. It is expected that harmonic distortion levels will fluctuate with various loading equipment and loading type connected to the system. As such, without further study consisting of constant metering over a set period, TWN provides harmonic distortion results for informational purposes only.

(See Section 10.1.3 for more details and IEE 519 analysis methods)

Distribution Reliability Results

IEEE 493 was used as the basis for the distribution reliability study. The intent of the study is to establish a base line for future assessment of changing reliability. The result is summarized as follows:

1. Reliability of the system under normal operating configuration would be near: 100%
2. The loss of service across ANY Load (i.e. a disruption of svc) is: 13.78 hrs/year

These statistics are primarily impacted by the sourcing and configuration of the system. It is noted that the driving factor behind the reliability is provided by the Utility and Generators. The backup generators associated with individual buildings do exist. To the extent that they are maintained and used in the event of an outage, this would positively impact reliability.

Distribution reliability evaluation summary is provided in Section 10.2 and a complete Reliability report is provided in Volume 2 Appendix O for the primary distribution system.

Oil Sampling Results

For this base, no oil samples were collected as it was De-Scoped from this Base's Study. Please see Section 10.3 for details.

Thermal Imaging (IR) Results

Thermal Imaging (IR) surveys were De-Scoped from this Base's Study. Please see Section 10.3 for details.

Recommended Projects

In the analysis of the documentation, field data, future infrastructure projects and study results, deficiencies have been identified, and resolutions (projects) are provided in Section 11.

Table 4
Recommended Electrical Infrastructure Projects

Dyess - Total Budget				
Index	Projects & Recommendation		Budgetary Estimate (\$)	Expanded Overview Supporting Recommendation
	PROJECTS		\$8,156,500	
1	Cable Tags		\$634,000	Limited cable tags were found during Data Collection. Cable tagging recommended inclusive of: Development of naming convention and individual labels, purchase of materials, printers, etc. Installation of label tracing cable to and from locations. Estimate for # of cables: 1,268 resulting in 2,536 tagging locations.
2	Alpha and Bravo Substation		\$7,500,000	Upgrading Alpha and Bravo Substations would significantly enhance their capacity to handle the upcoming load and reduce equipment wear and tear. Please note that this estimate is preliminary, and additional details are required to provide a more accurate budgetary estimate.
3	Label Manholes		\$22,500	Several unnamed Manholes were found during Data Collection. This project includes: - Development of naming convention to facilitate equipment tracking and their respective individual labels. Also, includes purchase label materials, printer, etc. - Installation and tack weld labels.
	Replacement of overdutied equipment (Svc Entrance / Bkr / Panel)		\$113,325 Budget Represents 46 Locations	Overduty equipment requiring replacement (Price is per breaker).
	Breaker / Fuse Replacement / Sizing (Coordination / Sizing Considerations)		\$319,050 Budget Represents 126 Locations	Replacements recommended due to sizing and/or coordination or Arc Flash
	Maintenance, Repair and Replacements		\$271,160 Budget Represents 625 Locations	Material Condition: The existing Transformers and Service Entrance panels are in various states of disrepair. They are missing fasteners, shows signs of corrosion, missing dead-fronts, and/or not installed per the manufacturer's instructions. They should be repaired and maintained.
	Studies & Training		\$1,225,180 Budget Represents 6 Studies	
	Year			
801	2025	Arc Flash Hazard Training	\$5,500	Provide NFPA 70E based arc flash hazard training to installation personnel
802	2025	Power Factor Study	\$96,000	To further investigate the reason for the sixty-four (64) transformers with a power factor below 90%, it is recommended to conduct a power factor study on each affected transformer
803	2025	Peak Load Study	\$9,000	To further investigate the three (3) transformers that do not meet NEC 450.3, performing a Peak Load study on each transformer will allow for proper service entrance protection sizing.
804	2028	Power System Study five (5) year required update	\$210,000	
805	2025	Grounding study of Installation	\$240,000	An important aspect of any electrical system is the earth grounding. A study should be performed periodically for the following reasons: • Existing earth grounding system complies with original design. • Changes to the existing earth grounding system have been properly recorded. • The earth grounding system performs to design performance and/or acceptable standards.
806		Yearly preventative maintenance and testing	\$664,680	The electrical distribution system equipment should be periodically inspected and tested. This recommendation applies to all equipment included in this study.
	TOTAL		\$10,085,215	

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1

INTRODUCTION

1.1 Purpose of Study

The purpose of this study is to perform an electrical analysis of the primary electrical distribution system. The project scope is specified in *Performance of Work Statement – Power System Modeling and Analysis (May 31, 2023) – (Order # FA805123F0032 / Contract # GS23F0182R)*.

The project activities consist of three distinct phases:

1. Phase 1: Conduct field surveys and testing to support a detailed “as-building” of the existing primary electrical distribution system.
2. Phase 2: Perform an electrical power system analysis of the existing primary distribution system, including power flow, short circuit, and electrical protection/coordination. The electrical analyses are performed using EasyPower® electrical analysis software. The study serves to baseline performance of the existing system in support of a detailed engineering evaluation of the primary distribution system.
3. Phase 3: Conduct a detailed engineering evaluation of the primary electrical system to establish future modifications, expansions, and upgrades to support future electrical requirements and improve system efficiency, reliability, and maintainability.

A flowchart of project activities is shown in Figure 1-1.

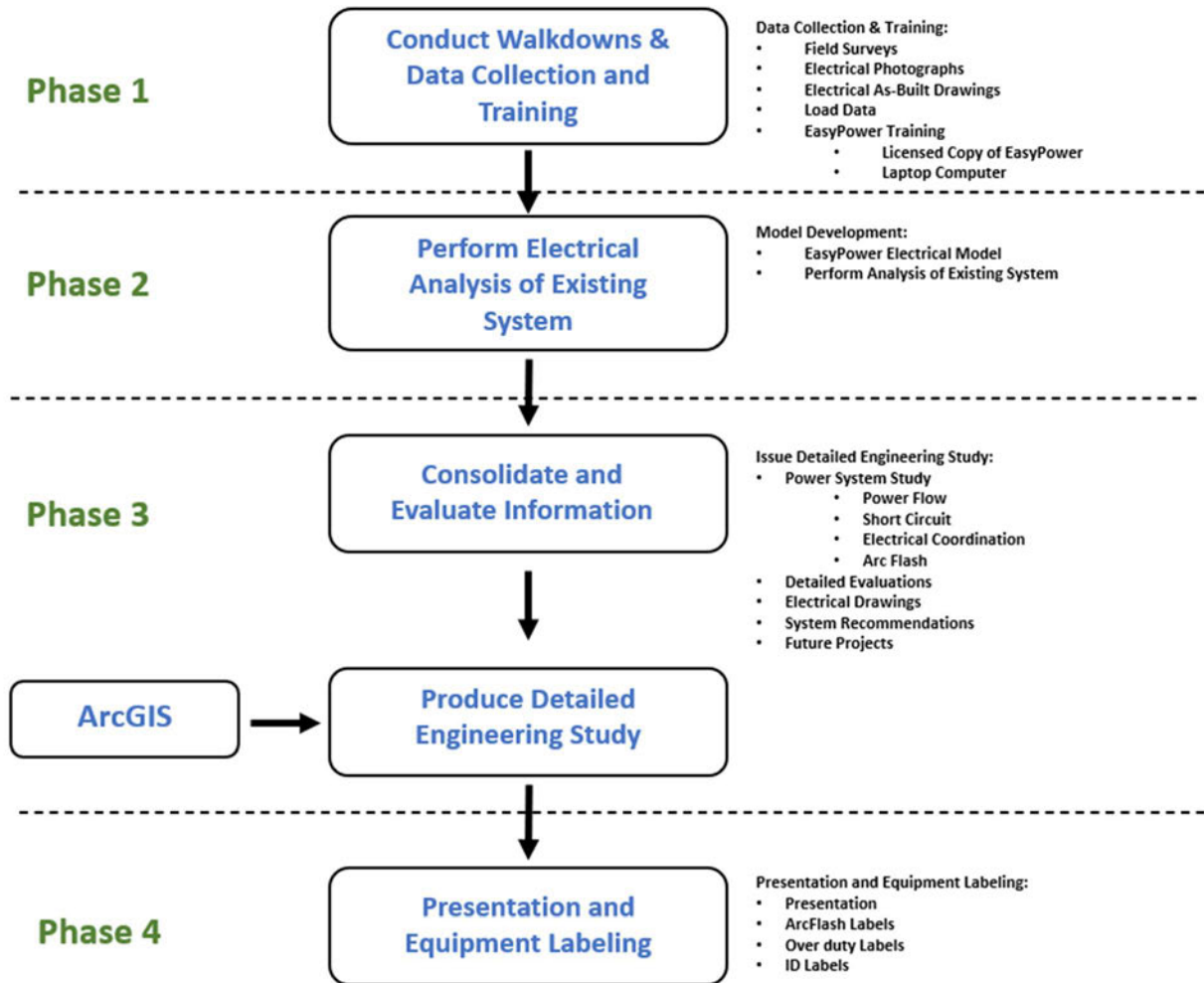


Figure 1-1
Flowchart of Project Activities

1.2 Power System Study

The Power System Study documents the results and findings of an engineering analysis for the existing electrical power distribution system. The analyses conducted include:

- Power flow
- Short circuit
- Arc flash
- Electrical protection and coordination
- Harmonics
- Motor starting

- Distribution Reliability

The various analyses, as a group, provide design confirmation of the inherent ability of the electrical power distribution system to perform reliably under normal and abnormal conditions. The analyses are conducted using a specialized electrical analysis software program – EasyPower®, a Microsoft Windows® graphical-based electrical power systems analysis program. To conduct an engineering study of this type, an electrical model of the power system is first developed. Once the model has been created and primary distribution data is input into the software, the desired analyses can be performed.

The following activities are completed as part of conducting the analyses:

- Gather necessary primary distribution system data, including a walkdown of the system configuration and collection of service entrance loading data.
- On-site generation information was collected using Dranetz and manufacturer's data sheets to obtain source data for input into the model.
- Using the walkdown data and utility interface/source data, develop an EasyPower model for the electrical distribution system.
- Perform a power flow analysis, including motor starting studies. Include a contingency analysis of cross-connection capability between feeders and/or loop circuits. Include motors 50 Horsepower (Hp) and larger in the analysis.
- Perform short circuit calculations and evaluate the suitability of system equipment for the available fault current (i.e., equipment duty assessments).
- Evaluate electrical overcurrent protective device coordination, including alternate system lineups as appropriate. Provide recommendations for setting changes to improve electrical protection and coordination.
- Evaluate the harmonic distortion and power factor for the electrical distribution system and recommend changes as needed (Note: Based on instantaneous spot measurements).
- Perform an arc flash analysis for the primary distribution system.
- Perform reliability base line analysis for the primary distribution system.
- Provide recommended conceptual design changes for single point of failure for the primary distribution system.
- Provide updated layout and single-line diagrams of the primary electrical distribution system to include component sizes and general nameplate information. The updated single-line diagrams utilize AutoCAD software and will be provided as hardcopy and electronic files. The specific format and layout of the drawings will be tailored to comply with Base conventions and standards.

- Provide the EasyPower software and data files used to conduct the studies.
- Provide field verification data in database format in accordance with the latest version of Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE).
- Other minor related tasks as specified in the SOW.

1.3 Deliverables

The following deliverables are provided in support of this power system study:

- Analysis report summarizing project findings and results.
- Field walkdown data files – on DVD.
- EasyPower electrical model for the primary distribution system.
- Electronic copies of photographs taken of electrical equipment during field walkdowns – on DVDs.
- Oil sampling and testing reports of all Substation transformers.
- Thermal imaging reports of the same Substation transformers.
- EasyPower software and associated training.
- Laptop computer capable of running the provided EasyPower software.
- New electrical distribution system single-line drawings.
- New electrical layout drawings.
- Arc Flash Labels.
- Equipment identification Labels, as identified.
- Equipment Geospatial Data (ArcGIS model).

1.4 Description of Analyses

Brief descriptions of the individual analyses conducted as part of this engineering study are provided below.

1.4.1 Power Flow

A power flow study is commonly called a load flow study; the terms are used synonymously. A power flow study determines voltages and power flow throughout the primary electrical distribution system. The study provides insight into many aspects of system performance, including:

- Adequacy of voltage levels throughout the system.
- Current flow through all branches of the system.
- The ability of generators to supply required load without exceeding their rating.
- The ability of system equipment (such as switchgear, panels, transformers, or cables) to carry the required load without exceeding equipment ratings.
- Inappropriate or low reliability system lineups, including an evaluation of cross-connect and alternate feed capability.
- System expandability and choke points for load addition.
- Equipment sizing and rating specifications for new/replacement equipment.

Usually, a power flow study includes an analysis of system performance under various conditions and operating modes. Different conditions of interest might include:

- Cross connect capability between the feeders (partial or full).
- Proposed load additions.
- System changes involving re-powering loads from a different feeder (load re-balancing).
- Variations in transformer tap settings.

1.4.2 Short Circuit

Even the most carefully designed electrical power system can, from time to time, be subjected to short circuits that produce potentially damaging levels of fault current. High level currents that flow during an electrical fault can produce severe arc-blasts, overheating, and magnetic forces that result in personnel injury, catastrophic equipment failure, fire, and/or prolonged down time. A short circuit study determines the available fault current throughout the system. These fault currents are compared to the short circuit rating of the equipment to confirm that the ratings are not exceeded.

A short circuit study provides a means to evaluate the following aspects of a power system:

- The ability of a system's primary distribution equipment (such as switchgear, cables, disconnect switches, panels, motor control centers, or bus ducts) to withstand the available fault current without damage.
- The ability of system protective devices (e.g., circuit breakers, fuses) to successfully interrupt a fault.
- The adequacy of electrical protective device settings and sizes.

- System lineups that realize unacceptable levels of fault current.
- Baseline fault current levels for calculating arc flash energy levels.

Short circuit current levels for several types of faults are generally evaluated during a short circuit study, including:

- *Three phase bolted fault* – all three phases of a three-phase system short together with no appreciable fault impedance (generally produces the highest available fault currents and always produces the most fault energy).
- *Phase-to-ground fault* – one phase of a three-phase system shorts to ground (also called a line-to-ground fault or ground fault).
- *Phase-to-phase fault* – two phases of a three-phase system short together (also called a line-to-line fault).
- *Phase-to-phase-to-ground fault* – two phases of a three-phase system short together and to ground simultaneously (also called a double line-to-ground fault).

An evaluation of a system's short circuit capability is critical for the assessment of personnel and property protection. This aspect of system performance can only be determined through design analysis since normal operation offers no information regarding the system's ability to handle a severe short circuit. Faults are an infrequent event; thus, an underrated system can operate for years or even decades without any apparent problems. The shortcoming only becomes evident when the system is subjected to a fault. For this reason, all governing codes, standards, and regulations clearly state the importance of not exceeding equipment short circuit ratings.

NFPA 70-2023 clarifies the interrupting rating and short-circuit current rating criteria for electrical distribution equipment with the following statements:

Article 110.9 Interrupting Rating:

Equipment intended to interrupt current at fault levels shall have an interrupting rating at nominal circuit voltage at least equal to the available fault current at the line terminals of the equipment...

Fuses or circuit breakers that do not have adequate interrupting ratings could rupture while attempting to clear a short circuit...

Article 110.10 Circuit Impedance, Short-Circuit Current Ratings, and Other Characteristics:

The overcurrent protective devices, the total impedance, the equipment short-circuit current ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective devices used to clear a fault to do so without extensive damage to the electrical equipment of the circuit...

Wire, bus structures, switching, protection and disconnect devices, and distribution equipment all have limited short circuit ratings and would be damaged or destroyed if those short-circuit ratings were exceeded...

1.4.3 Arc Flash

The nature of equipment arcing failure and the rate of serious burn injuries in the electrical industry have been studied for many years. Detailed investigation into the arc flash phenomena by many researchers has led the NFPA to adopt arc flash guidelines in NFPA 70E, *Electrical Safety in the Workplace*, for work on or near energized electrical equipment. IEEE-1584, *IEEE Guide for Performing Arc Flash Hazard Calculations*, was issued to provide a calculation methodology and equations for determining arc flash energies. Together, these guidance documents add a new dimension to traditional electrical power analysis.

Arc flash hazard studies require knowledge of both the electrical power system and the system's electrical protection. Arc flash studies can be considered a continuation of the short circuit and electrical coordination characteristics of a power system, since the results of each are required to assess the incident energy associated with an arc flash event at any specific location in the power system. Numerous design and configuration factors can affect the calculated arc flash energy levels. Thus, development of an electrical analysis model for the purpose of arc flash calculations requires a level of detail.

An arc flash study accomplishes the following:

- Calculates arc flash incident energy levels at key locations throughout the system.
- Provides a basis for protective personal equipment (PPE) requirements based on arc flash analysis results for specific work locations.
- Evaluates potential equipment line-up or protective device setting changes that can reduce the arc flash hazard at specific locations.
- Identifies locations in which energized work cannot be conducted safely regardless of available PPE.

AFMAN 32-1065, *Grounding & Electrical Systems*, states that “work on energized equipment is prohibited except in circumstances when justified by and approved by the Base Civil Engineer (BCE) or equivalent.” AFMAN 32-1065 also explains the requirements associated with working on energized circuits. An arc flash study is an integral part of this process and will help establish the PPE requirements for the work location.

1.4.4 Electrical Protection and Coordination

A coordination study is a graphical analysis of a system's electrical protective devices (overcurrent relays, circuit breakers, and fuses). The term *coordination* comes from the basic intent of the study, which is to evaluate how well a system's overcurrent protective devices coordinate with each other during an overcurrent condition (short circuit or overload) to isolate an unwanted electrical event and protect other equipment from damage. The objective is for the protective

device closest to the fault to operate before any other upstream protective devices operate, thereby limiting the portion of the system affected by the fault.

A properly protected and coordinated system will:

- Rapidly isolate a faulted circuit at the closest possible point upstream of the fault, while minimizing disruptions to unaffected portions of the system.
- Minimize damage to the faulted circuit or equipment by rapidly removing it from service.
- Minimize the possibility of damage to equipment upstream of the fault that “sees” the fault current but is otherwise unaffected.
- Minimize the possibility of catastrophic equipment failure, fire, and personnel hazards.

Ensuring proper electrical protective device settings is important to maintaining a reliable and safe electrical power distribution system. In many instances, the root cause of major power outages, fires, and equipment failures can be traced back to an improperly coordinated system.

1.4.5 System Cross-Connect Capability

The evaluation of system cross-connect capability is part of the power flow analysis, but it is listed separately here because of its importance to system reliability. The system is evaluated with respect to its ability to provide power through its various points of cross-connect. This type of evaluation is important for the following applications:

- Determine the impact of removing a single supply feeder from service.
- Determine means of supplying power to individual loads when the normal source has been lost.

1.4.6 Harmonics

Voltage and current harmonic data are obtained by spot field measurements as part of the walkdown process. A harmonics analysis is conducted to evaluate the magnitude of distortion in the electrical voltage and current waveforms that results from electronic loads either radiating and/or conducting harmonics onto the power system. Distorted waveforms, if severe enough, can cause problems to certain types of equipment. Detrimental effects associated with harmonics include:

- Overheating of transformers.
- Overheating of neutral conductors due to excessive current.
- Inaccurate performance of protective relays.
- Equipment malfunction.

In conducting a harmonics study, distortion of both the voltage and current waveform is reviewed, with emphasis placed on voltage waveform distortion. Analytical harmonic studies can be performed; however, they are quite sensitive to system parameters that are not always easy to determine accurately. For an existing system, the best method of analyzing harmonics is by recording measurements over a long period of time at the various points of concern.

System harmonics are specified as a percentage of the total harmonic distortion (THD). For example, a voltage THD of 2.1 percent means that 2.1 percent of the voltage waveform is composed of frequencies other than the fundamental frequency (60 Hz or 50 Hz depending on location).

1.4.7 Motor Starting

A motor starting study is a specific type of power flow study. The objective of a motor starting study is to confirm that the inrush current associated with starting a large motor does not cause voltage at the motor's terminals to drop below a level that prevents proper motor start. The study also checks whether the predicted voltage drop due to starting a motor is significant enough to affect other loads.

A motor starting study is performed by conducting a power flow analysis with the motor of interest modeled in a start condition. The power flow analysis results then provide predicted voltages under the postulated motor start conditions. The voltages are compared to the typical limits established by a motor manufacturer to confirm acceptability.

1.4.8 Cold Load Pickup

The objective of the Cold-Load Inrush study is to assess the ability of energizing a primary distribution feeder following a feeder outage. The study considers transformers inrush-magnetization and starting of all motors by feeder.

EasyPower standard modeling parameters were used to represent the effects of transformer inrush and potential impacts relative to protection settings. Motor starting was accomplished through the EasyPower tools under the assumption of all motors starting simultaneously. As a note, it is recognized that the estimates for motor starting are worst case and may not be representative of real-world conditions.

1.5 Electrical System Modeling and Analysis Software

The primary electrical distribution system study was conducted using EasyPower, a Microsoft Windows graphical-based electrical power analysis program. With EasyPower, all system modeling is performed in a graphical environment in which a one-line representation of the electrical system is built. Behind the graphical one-line, the software establishes the "true" electrical model of the system. The electrical model consists of an impedance (admittance) network tied together through a matrix of analysis nodes. Figure 1-2 shows a typical EasyPower user interface.

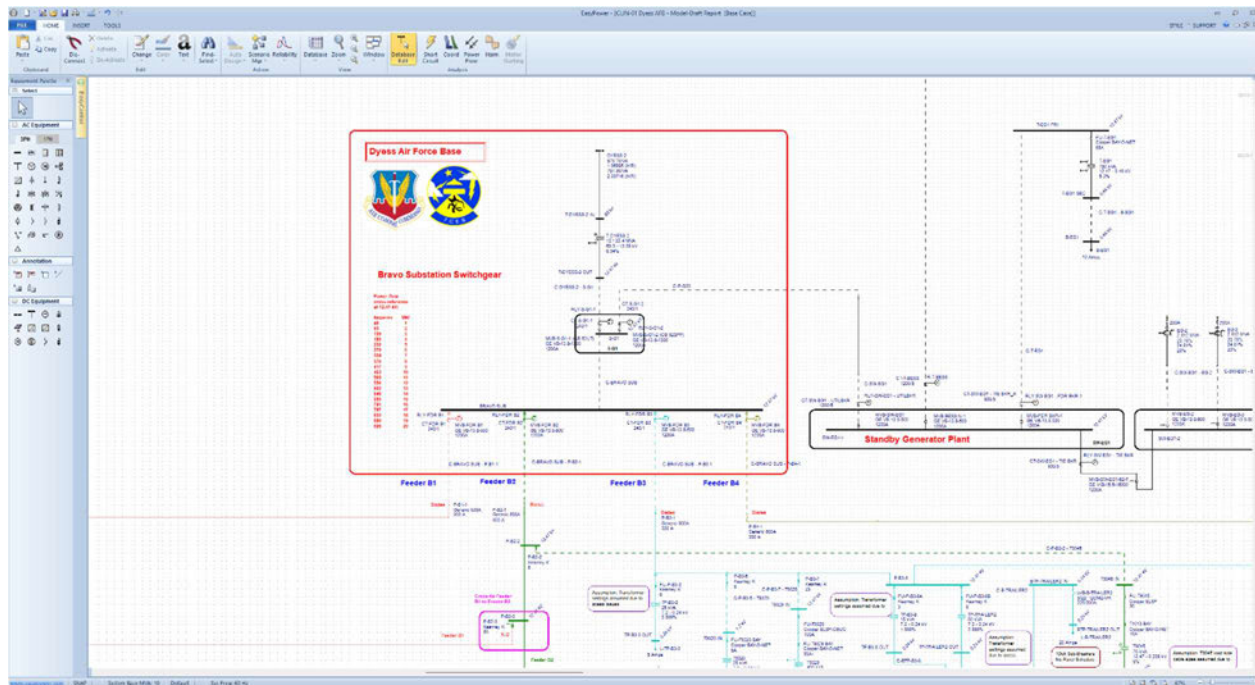


Figure 1-2
Typical EasyPower User Interface

An electrical model of the power distribution system is developed in the software and the completed model serves as the basis for all analyses. In addition to the graphical one-line, the software requires design and operating information about the various components in the system. This data is entered by the user and is stored in a project database that is maintained by the EasyPower software. A typical data entry screen is shown in Figure 1-3. The data entry window shown is for a typical distribution transformer.

Figure 1-3
Typical EasyPower Data Entry Window

Creating an EasyPower electrical model is relatively straightforward once all the system data is known. By far, the largest challenge and most time-consuming effort in creating the system model is obtaining the system configuration and component data. In many cases, it is only necessary to know the make and model of a component because EasyPower has a built-in *Device Library* for many common components. In this case, the user selects the make and model of the component in the data entry screen and EasyPower fills in the required data parameters.

Once the electrical model is developed, EasyPower is a convenient and time effective tool for conducting studies because the software allows virtually all key system parameters to be quickly adjusted, including:

- Opening and closing circuit breakers and switches.
- Turning equipment on and off.
- Varying load levels.
- Adjusting pre-analysis voltage levels.
- Changing transformer tap settings.
- Changing circuit breaker trip settings.

The contingency study capability of the software is one of its most powerful features. Proposed system changes can be quickly evaluated for suitability. In addition, different design options can

be compared with minimal effort. Contingency studies can also be conducted to evaluate changes in operating modes. For example, it might be useful to evaluate temporary power options for supplying a facility's loads if the normal service transformer must be removed from service for repair or replacement.

EasyPower analysis calculations are performed in accordance with current IEEE, NFPA, IEC, and ANSI standards. NEMA, IEEE, and UL circuit breaker rating standards are incorporated into the analysis algorithms, including adjustments to short circuit ratings based on system X/R ratios.

1.6 Analysis Process

The general activities associated with performing this type of engineering study are summarized below:

Step 1: Collect Design Information

- Electrical system drawings.
- Electrical equipment information (technical manuals, specification sheets, test data, etc.).
- System operating procedures and guidelines.
- Utility interface parameters.
- Past analysis and studies.
- Measured load readings or use of historic load profiles were available.

Step 2: Conduct Field Surveys and Walkdowns

- Confirm the as-built configuration of the system.
- Verify, to the extent possible, electrical design information.
- Collect data for equipment parameters not available from design documents.
- Determine protective device settings and sizes.
- Measure voltage, current, and power factor at strategic locations throughout the system to establish baseline operating values.
- Measure voltage and current harmonics at various locations throughout the system.
- Visually assess the material condition of electrical distribution system equipment.

Step 3: Develop the EasyPower Electrical Model

- Using design information and walkdown data, create the EasyPower one-line diagram.

- Using design information and walkdown data, populate the electrical model database.

Step 4: Perform System Analyses

- Determine operating modes and configurations of interest.
- Perform and document power flow, motor starting and cross-connect.
- Perform and document the short circuit analysis.
- Perform and document the electrical protection and coordination evaluation.
- Perform and document an arc flash analysis.
- Review harmonic data collected during field surveys.

Step 5: Evaluate Analyses Results

- Review analysis results.
- Recommend design and/or operating changes (conceptual) to correct identified problems and/or optimize system performance and reliability.
- Summarize analysis results and recommendations in a corrected final report.
- Provide a copy of the EasyPower model for ongoing use in evaluating future modifications and monitoring system performance.

2

DATA ACQUISITION AND MODEL DEVELOPMENT

Section 2 provides information regarding development of the model, typical approach for development, the field walkdown data acquisition process and the power system modeling process. It is noted that Section 2 is provided to summarize the general approach employed in the development of this study. The Database Report feature in EasyPower can be used to review the modeling data for each component in the model.

2.1 Field Walkdowns

Field surveys and walkdowns were performed to (1) confirm the as-built configuration of the electrical power system and (2) collect accurate data for modeling. Electrical information acquired from electrical system equipment during the field walkdowns is inclusive of:

- Utility supply capability, including protective device settings.
- Distribution system conductors – underground.
- Switchgear, including protective device settings.
- Distribution system transformers.
- Accessible service entrance equipment, including protective device settings.

In addition to collecting equipment data (make, model, size, settings, etc.) and confirming connection relationships, electrical power measurements were taken at low-voltage locations where power monitoring was possible in a safe manner. The spot measurements recorded include voltage, current, power factor, and total harmonic distortion (THD). The voltage, current, and power factor measurements were used during development of the electrical power flow for the primary electrical distribution system. A Dranetz HDPQ-EXPLORER-A power quality analyzer was used for these measurements.

The walkdown information was also used to develop the primary electrical distribution system one-line and layout drawings; these drawings have been provided as part of the project deliverables. Refer to Section 2.7.

Photographs were taken of equipment during the walkdown process. These photographs have been provided as part of the project deliverables. Refer to Section 2.8.

2.2 Inaccessible Equipment and Missing Data

During the initial project coordination meeting, inaccessible equipment was discussed in detail. Most of the information necessary to create a complete and accurate electrical model is available from electrical drawings or was determined by field surveys/walkdowns. Examples of component and configuration data not capable of being readily validated by walkdown include:

- Distribution system transformers with missing nameplates.
- Distribution system fuse or cutout sizes – typically difficult to confirm without requiring a partial (or complete) system outage, which was not planned for this study.
- Size and type of underground lines – in some cases, the conductor jacket labeling can be read at installed switches or on the primary side of distribution transformers. Where unavailable, available drawings and knowledge of exterior shop personnel were utilized.

2.3 Electrical Model Overview

Within EasyPower, a model is made up of three basic elements, as shown in Figure 2-1 and described below:

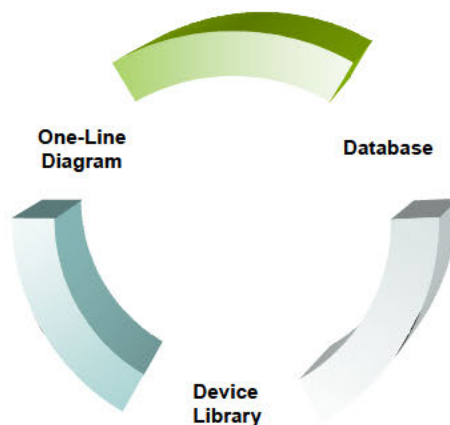


Figure 2-1
EasyPower Model Elements

- One-line diagram. The one-line diagram serves as the primary user interface. It is intended to have the “look and feel” of a typical electrical one-line diagram. From a computational perspective, the one-line diagram serves the important function of establishing analysis nodes that represent all the branches of the electrical network. Each bus in the model is treated as an analysis node.
- Database. Each component in the one-line diagram has various attributes that quantify and characterize the component. This information is needed by the software to perform the various

analyses. Component data is input by the user and is stored by EasyPower in a database. The database is integral to the project file and cannot be accessed separately.

- **Device library.** Each project file is linked to an EasyPower device library. The library is an EasyPower database that contains data for commonly used power system equipment and components. The library allows users to quickly populate equipment data fields since only the equipment make and model need be entered. The device library can be modified by the user to add components not included in the standard library.
- The EasyPower project file is named *CLIN-01 – Dyess AFB – Model-Final Report.dez*. The library file is named *stdlib_mod.mdb*, and this file is accessible from the EasyPower main menu.

2.3.1 Base Parameters

Base system parameters must be established for each EasyPower Project. The base parameters for this study are listed below.

Base MVA:	10	Units:	US		
Frequency:	60 Hz	Symbols:	ANSI	Model	ANSI

2.3.2 EasyPower Device Library

The equipment incorporated in the study is contained in the EasyPower default library (*stdlib.mdb*) with equipment additions based on as-found equipment. For this reason, a customized library is provided with the model (*stdlib.mdb*).

2.3.3 Analysis of Areas and Zones

EasyPower allows the user to define *Areas* and *Zones* for the system buses so that filters can be employed to run selective analyses. For example, in evaluating a proposed design change to a specific feeder, it might be desirable to run a short circuit study for a portion of the system, and not the entire system.

2.4 Equipment Naming Conventions

A modeled representation of the primary distribution system equipment requires a unique name for each component within a class of equipment. The focus is to have unique component names, within equipment categories, that align with a uniform naming convention. It is recognized that unique circumstances arise, and the specific naming conventions are used as a guideline for consistency within a model. The focus on naming follows four (4) fundamental principles:

1. A prior model was not developed, component names were assigned by naming convention.
2. Component names, within a category, follow a logical convention that provides a consistent and representative name for associated component.

3. Unique identifiers within the component's name align with the equipment's field label/location.
4. There is a general naming and nomenclature structure that is adopted when assigning component names, subject to software limitations for name lengths and unique circumstances that do not fit the specific naming convention.

In this study, a model was provided by the Installation, and current naming conventions were kept.

1. Each component name can be comprised of three fields for a name:
 - a. Field #1 is an identifier that represents the type of component.
 - b. Field #2 is an identifier that represents the components associated equipment. Items in parenthesis indicate what is physically on the field label. Example: B2222 (MAIN) would indicate that the physical label next to this breaker says "MAIN".
 - c. Field #3 is an identifier that provides a unique label (such as field label, location of component relative to associated equipment, etc.).
2. Some fields are considered optional based on the equipment class assigned by the model.

The naming convention for this model is as follows:

	Application of Naming Convention Fields		
Equipment Type	Field #1 Type of Equ	Field #2 Associated Equipment / Location	Field #3 Specific Identifier if Required.
Description	Name = "Type of Equ" + "Associated Equipment/Location Name" + "Unique Id"(as required) Note: Adjust as needed for Length Limitations and Special Circumstances		
Power Sources			
Utilities	UTIL	Label ID	
Generators	GEN	Label ID	
Power Equipment			
Transformer	T	UP Stream Connected Point/Device	Label ID
Pole Mount Transformer	TP	UP Stream Connected Point/Device	Label ID
Motors	MTR or ""	UP Stream Connected Point/Device	Label ID
Capacitor Bank	CAP or ""	UP Stream Connected Point/Device	Label ID
Cable, Transmission Lines, Connections & Infrastructure			
Cables	C	DOWN Stream Associated Equ Name	Unique ID (if needed)
Buses	BUS or "B"	Associated EQU NAME	XFMR: PRI/SEC Other: "b" or IN="" / OUT-LOAD

Busways	BW	DOWN Stream Associated Equ Name	
Poles	P	DOWN Stream Associated Equ Name	
Manholes	MH or P“#”	DOWN Stream Associated Equ Name	
Sectionalizer	SC	UP Stream Connected Point/Device	
Slice Point	SPL	UP Stream Connected Point/Device	
Junction Box	JB	UP Stream Connected Point/Device	
Switches & Stand-Alone Breakers			
Generic Switch	S	DOWN Stream Associated Equ Name	Unique ID (if needed)
Disconnect Switch	DSC	DOWN Stream Associated Equ Name	Unique ID (if needed)
Fused Disconnect Switch	FDSC	DOWN Stream Associated Equ Name	Unique ID (if needed)
Fused Switches	FS	DOWN Stream Associated Equ Name	Unique ID (if needed)
Automatic Transfer Switch	ATS	DOWN Stream Associated Equ Name	Unique ID (if needed) (i.e. 1/2 S1/S2)
Manual Transfer Switch	MTS	DOWN Stream Associated Equ Name	Unique ID (if needed) (i.e. 1/2 S1/S2)
Stand Alone Service Disconnect	SVCD	DOWN Stream Associated Equ Name	Unique ID (if needed)
High Voltage Breaker	HVB	DOWN Stream Associated Equ Name	Unique ID (if needed)
Medium Voltage Breaker	MVB	DOWN Stream Associated Equ Name	Unique ID (if needed)
Low Voltage Breaker	LVB or “BL”	DOWN Stream Associated Equ Name	Unique ID (if needed)
Panels			
Panels	PNL	Associated Location ID	Label ID + Unique ID (if needed)
Main Disconnect in Panel	MDP	Associated Location ID	Label ID + Unique ID (if needed)
Bus Representing a Distribution Panel where Main as Svc Disc & sub-brks not modeled	B	Associated Location ID	Label ID + Unique ID (if needed)
Distribution Panel where Main as Svc Disc & sub-brks are modeled	CDP	Associated Location ID	Label ID + Unique ID (if needed)
Secondary Distribution Panel	SDP	Associated Location ID	Label ID + Unique ID (if needed)
Equipment Lineups			
Generic Switchgear Lineup	SG	Associated Location ID	Label ID + Unique ID (if needed)
High Voltage Switchgear	HVSG	Associated Location ID	Label ID + Unique ID (if needed)

Medium Voltage Switchgear	MVSG	Associated Location ID	Label ID + Unique ID (if needed)
Low Voltage Switchgear	LVSG	Associated Location ID	Label ID + Unique ID (if needed)
Medium Voltage Center	MVC	Associated Location ID	Label ID + Unique ID (if needed)
Motor Control Center	MCC	Associated Location ID	Label ID + Unique ID (if needed)
Panel Board	B	Associated Location ID	Label ID + Unique ID (if needed)
Switch Board	B	Associated Location ID	Label ID + Unique ID (if needed)
Pad Mount Switch	SW	Associated Location ID	Label ID + Unique ID (if needed)
Protection			
Fuses	FU	Associated EQU NAME	
Relays	RLY	Associated EQU NAME	
Current Transformer	CT	Associated EQU NAME	
Other Devices			
Potential Transformer	PT	Associated EQU NAME	
Loads	L	Associated EQU NAME	
Meter	MT	Associated EQU NAME	
Location Designators			
Load at Location	L	Location ID	
Building	B	Location ID	

2.5 Modeling of Individual Components

2.5.1 Utility Connection

The local utility, or on-site generation technical information was provided by the client and/or utility, including how it connects and the available short circuit current at the substation input.

2.5.2 Buses

In the terminology of modeling, a *bus* is any point to which equipment is attached. All equipment must be associated with a bus and conductor connection points must be to a bus. Buses are designated by voltage class and are categorized based on equipment type. EasyPower treats each system bus as a modeling connection point for analytical computations. Thus, analysis results are provided for each bus. Not all buses are of interest; some only serve to provide the connection point between cables and other equipment. For these situations, buses are inserted in the model as analysis nodes. These nodes appear as “dots” in the model, as shown in Figure 2-2. The identification (name) of each node can be displayed or suppressed depending on the user’s preferences.

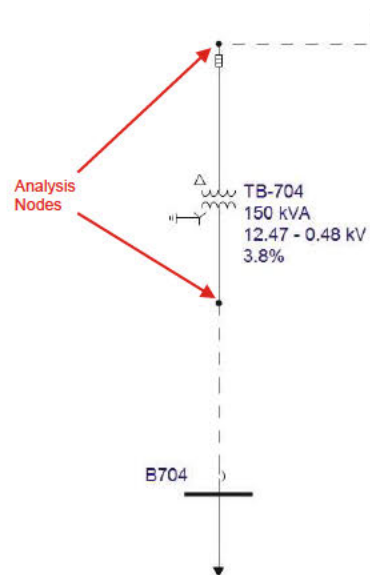


Figure 2-2
Example of EasyPower Analysis Node

Analysis results (per unit voltage and fault current) are suppressed on the one-line for these analysis nodes, thereby allowing a less cluttered user interface. Although results are not displayed for analysis nodes that have been reduced to “dots”, the results are readily available for these locations by expanding the dot to a typical bus representation. Text reports provide results for all buses. Analysis nodes are most often used for cases in which a component is connected to a conductor. Cables (conductors) have a measurable impact on the calculated voltage drop and short circuit current and are therefore included in the model to obtain accurate results.

The designations used in the model for system buses are generally based on the distribution transformers associated with the buses. For example, the service entrance bus for Transformer T-B-100 is named “T-B-100 IN”.

2.5.3 Feeders

The Base primary electrical distribution system consists of underground and overhead distribution. Underground distribution conductor sizes were typically confirmed at above ground equipment connections, service entrances or system design drawings, where available.

2.5.4 Transformers

2.5.4.1 Field Walkdown Data

Nameplate data were recorded for all accessible transformers, which generally applied to pad-mounted transformers. The field walkdown results are tabulated in Volume 2 Appendix E. The following information is assessed:

- Identification number – a unique number assigned to each transformer.

- Source – the closest source in the primary distribution system that provides power to the transformer.
- Manufacturer.
- Primary and secondary voltage.
- Primary and secondary connection – delta-wye, wye-wye, etc.
- Rating – kVA rating.
- Impedance.
- Transformer class – typically OA (ONAN) for most distribution transformers.
- Mounting – either pad-mount or pole mount.
- Comments.

2.5.5 HV/MV breakers

Where safely possible, and accessible, breakers were field verified with respect to make, model, and ratings. The breaker specifications are included in the EasyPower model so that their suitability with respect to short circuit and continuous current capability can be evaluated. EasyPower automatically adjusts the breaker interrupting rating based on nominal system voltage, as specified by ANSI C37 criteria.

EasyPower includes overcurrent relays in its modeling library and the protective relays have been modeled using their existing settings.

2.5.6 Service Entrance

2.5.6.1 Scope of Service Entrance Review

This project is a primary distribution system evaluation to the service entrance. Service entrances are field verified for the primary distribution system.

2.5.6.2 Low-Voltage Breakers

Low-voltage breakers at each facility service entrance are included in the model where the facility's electrical room could be accessed. The facility service entrance panel was inspected to obtain breaker interrupting and continuous current ratings. Make, model, size, and settings were determined for breakers during field walkdowns. In some cases, the exact breaker model type could not be determined, usually because of the age of the breaker or because of the panel configuration. Panels and switchboards were not disassembled to obtain this information.

Often the interrupting ratings could not be determined by visual examination of the exposed breaker housing; however, it was not considered prudent to deenergize the facility solely to

determine the breaker rating, as the focus of the project is the primary distribution system. Similarly, if the instantaneous setting of an adjustable breaker could not be determined, it was assumed to be set to HIGH.

2.5.6.3 Fused Disconnects

Fused disconnect switches (safety switches) are also used for the service entrance disconnect point. Nameplate ratings for the switches are included in the model, with fuse type and size included for the time-current characteristic curves used in the coordination analysis. Some disconnect switches could not be opened to verify fuse size. In these cases, representative fuse types were specified based on the switch voltage, model, and rating.

2.5.6.4 Solid-State Trip Units

Some service entrance breakers use solid-state trip units. In some cases, the panel could not be opened while energized to verify trip unit settings. In these instances, typical settings were used with the instantaneous trip set to its maximum value. If there is ever a problem with coordination at these locations, the EasyPower model provides a reasonable basis for adjusting the as-found settings.

2.5.6.5 Loads

When measuring load at a specific point, a Dranetz HDPQ-EXPLORER-A is utilized. Loading is treated as an estimated peak demand in the EasyPower model at the service entrance bus.

2.6 Database Summary

The *Database Report* feature in EasyPower can be used to review the modeling data for each component in the model. The following summarizes the number of key components included in the model(s):

Existing	Qty.
Base MVA	10
Frequency (Hz)	60
Buses	2810
Utilities	3
Generators	7
Transmission Lines	366
HV Breakers	50
Relays	48
Loads	609

Capacitors	10			
Rectifiers	2			
Photovoltaics	2			
Batteries	2			
		#Assumption	%	Comments
Cables	1267	33	2.60%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the cables, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Transformer	496	110	22.18%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for various transformers, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
LV Breaker	295	49	16.61%	Due to safety considerations associated with energized panels and removal of covers while energized, access to covered name plate data for the LV breakers was in-accessible. Under this condition, engineering estimates based on similar conditions, prior studies and existing conditions were made. Specifically related to name plate and/or trip setting.
CTs	48	1	2.08%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the CTs, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Motors	24	7	29.17%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the motor, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Fuses	1132	23	2.03%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the fuse, modeling selection was based on engineering estimates, field collected data,

				prior studies and/or similar conditions for the installation.
Switches	187	2	1.07%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the switch, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.
Sectionalizer / Junction Box	123	1	0.81%	Due to "No-Labeling" and/or "non-legible" conditions associated with name plate data for the Sectionalizer/Junction Box, modeling selection was based on engineering estimates, field collected data, prior studies and/or similar conditions for the installation.

2.7 Electrical Drawings

Electrical one-line and layout drawing updates have been provided as part of this project. It is noted that development and/or creation of one-line drawings are limited to pertinent information associated with requirements of a one-line and modeling. The updates provided are as follows:

- An oversized version of the layout drawing has been provided.
- An oversized version of the one-line diagram map has been provided.
- PDF and AutoCAD versions of the drawings are also provided for the Draft, Final, and Corrected Final Report. The electronic AutoCAD files are included on a DVD for the Corrected Final.

Feeder colors were selected for these drawings so that each feeder can be readily identified on the drawings. The feeder colors are identified on the electrical drawings.

2.8 Equipment Photographs

Over 23,000 photographs were taken of system electrical equipment during the walkdown process. These photographs have been provided with the report in a set of DVDs. The photographs are stored in a series of file directories, sorted by equipment identification number. Figure 2-3 shows an example of the directory structure.

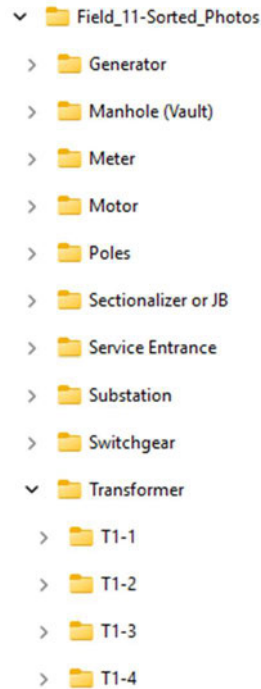


Figure 2-3
Equipment Photograph Directory Structure

2.9 GeoBase Equipment Data Files

Equipment data files were developed for the following types of primary distribution system equipment:

- Transformers.
- Pad-mounted Switches.
- Power Poles.
- Sectionalizers.

Primary distribution equipment positions were determined by resource grade GPS (Trimble TDC150 and satellite correction service Geospatial Continental Field Point RTX 1Y). GIS GeoBase data was initially entered in a series of Excel files, which are contained in the enclosed DVD. The conversion to a GeoBase-compliant GIS database was accomplished using ESRI ArcGIS and the data is stored in the GeoBase directory in the enclosed DVD. Common Installation Picture (CIP) data for structures and roadways were obtained from Base personnel. The final product is delivered in ESRI personal geodatabase format and is intended for viewing in ArcGIS.

Primary distribution cable routing is represented by generalized locations of electrical cable group lines and associated tabular data. Cable line locations were digitized based on generators, switches,

transformer, and service entrance locations as well as AutoCAD electrical layout drawings for general reference. Tabular attribution was accomplished through the reference of AutoCAD one-line electrical drawings.

The electrical one-line drawings described in Section 2.7 also show conductor sizes throughout the primary distribution system.

3

ELECTRICAL DISTRIBUTION SYSTEM DESCRIPTION

Section 3 provides an overview of the Installation's primary electrical distribution system.

3.1 Dyess AFB Overview

The location of the primary electric distribution system is shown in Figure 3-1. Figure 3-2 shows an aerial view of the primary electric distribution system.

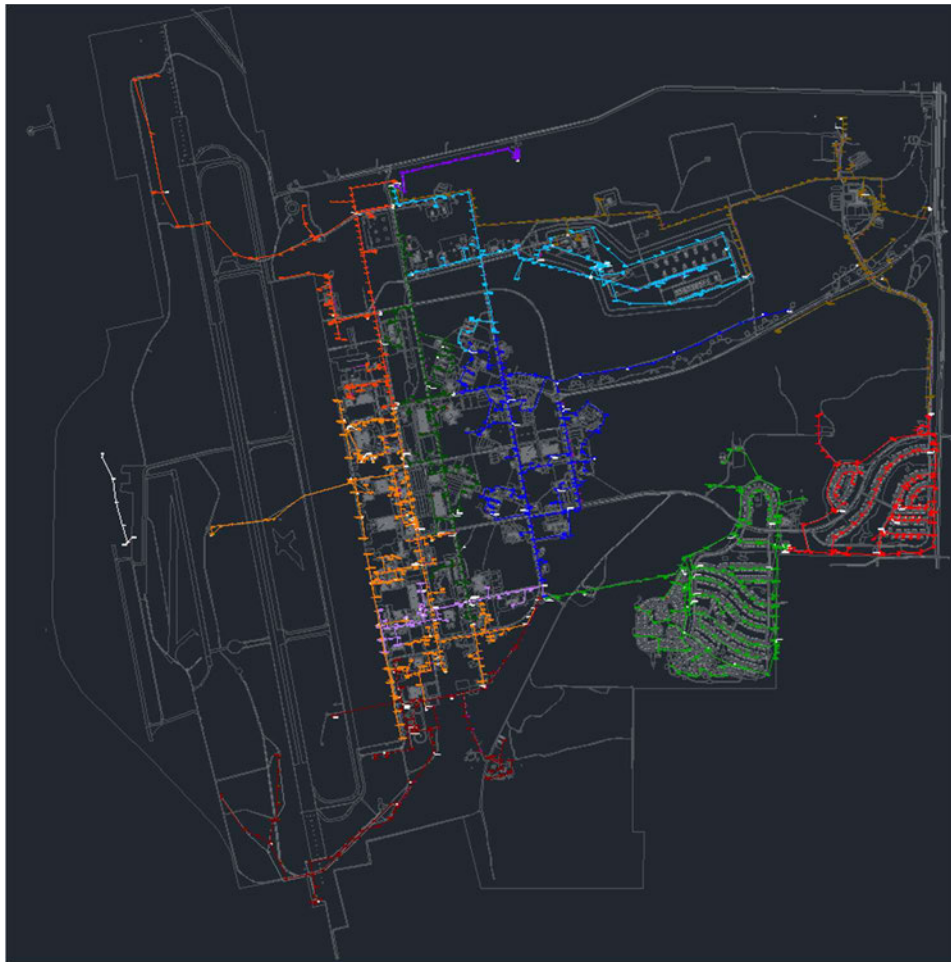


Figure 3-1
Dyess AFB Location



Figure 3-2
Dyess AFB – Aerial View

3.2 Primary Distribution System

3.2.1 Overview

The primary distribution system consists of underground and overhead distribution. The following summarizes typical characteristics of the distribution system configuration:

- American Electric Power (AEP) Texas utility is at 69 kV, three (3) phase and 60 Hz.
- Power is delivered to Dyess AFB through three (3) substations: Alpha, Bravo, and Charlie. Each substation is equipped with a switching station. The Alpha and Charlie substations, along with their respective switching stations, and the switching station associated with the Bravo substation, were included in this study.

- Underground distribution lines are conductors sized: 250 kcmil, 4/0 AWG, 1/0 AWG, 2 AWG, 2/0 AWG, and 1 AWG.
- Overhead lines are conductors sized: 4/0 Penguin, 4-6 Swan, 477 Pelican, 795 Condor, 2-7 Sparate, 2-6 Sparrow and 2/0 Quail.

3.2.2 Switchboards

There are several Switchboards and molded case circuit breakers (MCCB) throughout the installation. MCCBs feed loads locally to the Switchboards.

3.2.3 Facility Service Entrances

Facilities / Building service entrances are typically outdoor / indoor mounted panelboards.

3.3 Electric Supply

3.3.1 Overall Layout

Figure 3-3 shows a simplified one-line diagram of the primary electrical distribution system.

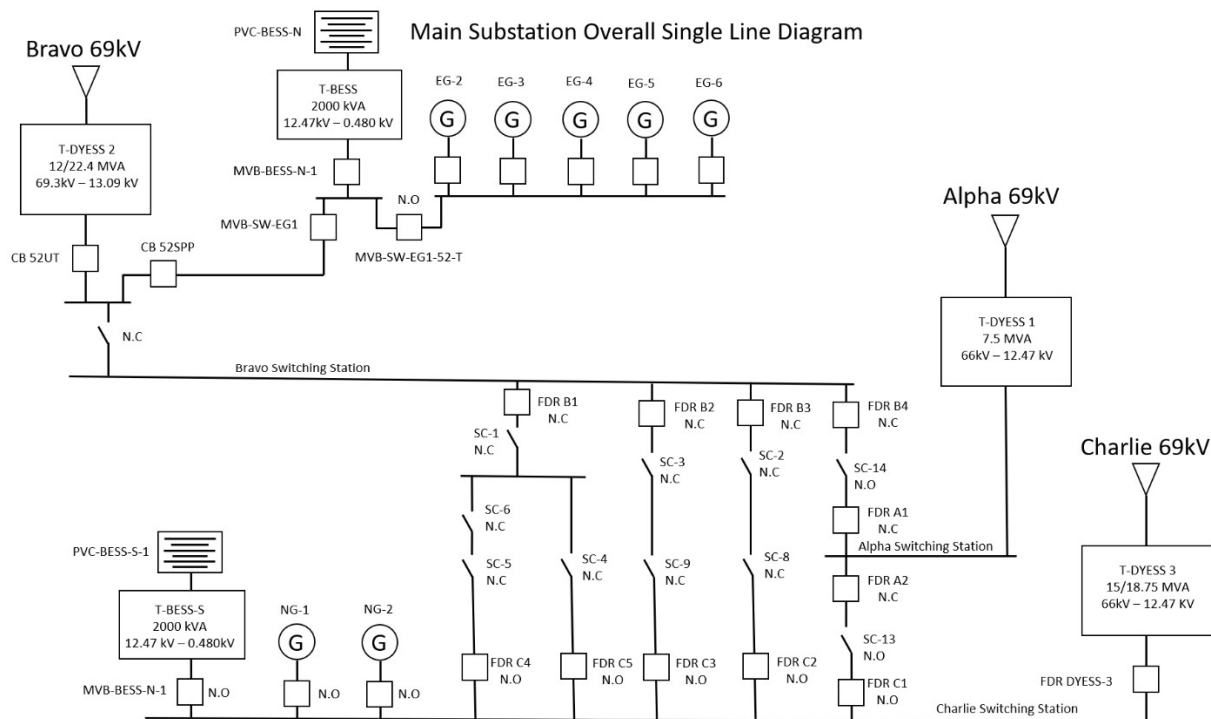


Figure 3-3
Dyess AFB - Simplified One-Line Diagram

3.3.2 Available Short Circuit Current

The Utility provides the main source of short circuit currents available throughout the circuit. Refer to Table 3-1 for a summary of the available short circuit current. These values are used as the basis for the short circuit study.

Table 3-1
Utility Main Substation Short Circuit Current

Utility	Short Circuit Type	Voltage Reference	Fault Current
AEP Texas Alpha 69kV Line	Three Phase	69 kV	982.1 MVA
	Single line to ground	69 kV	727.1 MVA
AEP Texas Bravo 69kV Line	Three Phase	69 kV	973.7 MVA
	Single line to ground	69 kV	757.9 MVA
AEP Texas Charlie 69kV Line	Three Phase	69 kV	808.9 MVA
	Single line to ground	69 kV	574.6 MVA

3.3.3 Overcurrent Protection

Overcurrent protection is provided by a main breaker/relay on each feeder and/or distribution equipment. (Refer to Table 3-2, Table 3-3, and Table 3-4). For additional Neutral / Ground Overcurrent Protection settings, refer to Appendix R – Compiled OCPD Information Table.

Table 3-2
Dyess AFB Alpha Switchgear Overcurrent Protection Data

Relay	FDR A1	FDR A2
Model	GE SR 760	GE SR 760
CT ratio	1200/5	1200/5
Phase Settings		
Tap (pickup)	0.3 (360A)	0.3 (360A)

Time dial setting	1.2	1.2
Curve shape	U4 Extremely Inverse	U4 Extremely Inverse
Instantaneous	None	None
Neutral Settings		
CT ratio	1000/5	1000/5
Tap (pickup)	0.15 (150A)	0.15 (150A)
Time dial setting	1.2	1.2
Curve shape	U4 Extremely Inverse	U4 Extremely Inverse
Instantaneous	None	None

Table 3-3
Dyess AFB Bravo Switchgear Overcurrent Protection Data

Relay	FDR B1	FDR B2	FDR B3	FDR B4
Model	SEL-751	SEL-751	SEL-751	SEL-751
CT ratio	240/1	240/1	240/1	240/1
Phase Settings				
Tap (pickup)	1.25 (173.205A)	1.25 (173.205A)	1.25 (173.205A)	1.25 (173.205A)
Time dial setting	2.85	2.85	2.85	2.85
Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	12 (1662.77A)	15 (2078.46A)	15 (2078.46A)	10 (1385.64A)
Neutral Settings				
Tap (pickup)	0.5 (69.282A)	0.5 (69.282A)	0.5 (69.282A)	0.5 (69.282A)
Time dial setting	2	2	2	2

Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	None	None	None	None

Relay	RLY-S-G1-1	RLY-S-G1-2	RLY-SW-EG1-UTILBKR
Model	SEL-751	SEL-751	GE SR 750
CT ratio	240/1	240/1	1200/5
Phase Settings			
Tap (pickup)	2 (277.128A)	2 (277.128A)	0.68 (816A)
Time dial setting	2.5	2.5	6
Curve shape	U3 Very Inverse	U3 Very Inverse	IAC Short Inverse
Instantaneous	None	None	None
Neutral Settings			
Tap (pickup)	0.5 (69.282A)	0.5 (69.282A)	0.11 (132A)
Time dial setting	3.25	3.25	10.9
Curve shape	U3 Very Inverse	U3 Very Inverse	U4 Extremely Inverse
Instantaneous	None	None	None

Table 3-4
Dyess AFB Charlie Switchgear Overcurrent Protection Data

Relay	FDR C1	FDR C2	FDR C3	FDR C4
Model	SEL-751	SEL-751	SEL-751	SEL-751
CT ratio	120/1	120/1	120/1	120/1
Phase Settings				
Tap (pickup)	2.5 (300A)	2.5 (300A)	2.5 (300A)	2.5 (300A)

Time dial setting	2.85	3.23	3.1	3
Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	29.17 (3500.4A)	29.17 (3500.4A)	29.17 (3500.4A)	29.17 (3500.4A)
Neutral Settings				
Tap (pickup)	1 (120A)	1 (120A)	1 (120A)	1 (120A)
Time dial setting	4.8	4.8	4.8	4.8
Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	8.33 (999.6A) 0.2 sec Delay	8.33 (999.6A) 0.2 sec Delay	8.33 (999.6A) 0.2 sec Delay	8.33 (999.6A) 0.2 sec Delay

Relay	FDR C5	FDR GPR-C-G1	FDR GPR-C-G2	FDR IPR-C-C7
Model	SEL-751	SEL-751	SEL-751	SEL-751
CT ratio	120/1	1200/5	1200/5	1200/5
Phase Settings				
Tap (pickup)	2.5 (300A)	2.5 (600A)	2.5 (600A)	2.5 (600A)
Time dial setting	3	2.85	2.85	2.85
Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	29.17 (3500.4A)	29.17 (7000.8A)	29.17 (7000.8A)	29.17 (7000.8A)
Neutral Settings				
Tap (pickup)	1 (120A)	1 (120A)	1 (120A)	1 (120A)
Time dial setting	4.8	4.8	4.8	4.8

Curve shape	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse	U3 Very Inverse
Instantaneous	8.33 (999.6A) 0.2 sec Delay	8.33 (1999.2A) 0.2 sec Delay	8.33 (1999.2A) 0.2 sec Delay	8.33 (1999.2A) 0.2 sec Delay

3.3.4 Utility Source (Substations)

Dyess Air Force Base (AFB) operates and maintains three on-site switching stations, designated Alpha, Bravo, and Charlie. These stations are powered by adjacent substations managed by American Electric Power Texas (AEP Texas). The base also features an on-site diesel generator (DG) standby plant, which is connected to the Bravo switching station. The DG plant serves as a standby power source for the main base, ensuring power supply to Bravo and Charlie in the event of a commercial power outage.

3.3.5 Switchgear Protection

At the Substation, SEL and GE relays are used for protection at the medium voltage level. Throughout the rest of the distribution system, there is a combination of relays and fuses used for protection at the medium voltage level.

At the low voltage level, there are a combination of SSTs used. These include Sentron, Digi-Trip, Seltronic, Micrologic and Spectra RMS. Figure 3-4 shows an example of one of these relays. Some of these relays contain a ground element.

These relays fall into the Solid-State Trip (SST) category unlike an Intelligent Electronic Device (IED) category. SST provides no analytical assistance, historical databasing, or event recording.



Figure 3-4
Micrologic 6.0A

3.4 Underground Conductor Ampacity

Conductors are mainly in a conduit at this installation. Based on standard cable libraries made available in the model, each cable was designated based on as-found labeling or best estimates where specific cable sizing was not labeled or definitively indicated.

3.5 Primary Distribution System

3.5.1 Transformers

For a complete list of transformers see Appendix E.

3.5.2 Feeder Summary

Table 3-5 provides a summary of each feeder.

Table 3-5
Feeder Summary

Feeder	Description
FDR A1	Feeder A1 is fed from T-DYESS 1 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 350kcmils, 1/0 AWG, 2 AWG. Overhead cables are typically 2/0 Quail, 2-6 Sparrow, 2-7 Sparate, 4/0 Penguin. Feeder A1 feeds the following locations: T-25A, T-36A, T-43A, T-86, T-87, T-89, T1-39, T1-40, T1-41, T1-42, T1-43, T1-44, T1-45, T1-46, T1-47,

Feeder	Description
	T1-48, T1-51, T1-52, T1-53, T1-54, T1-55, T1-56, T1-57, T1-58, T1-59, T11981, T14402, TP11990, TR-61, TR-62, TR-63, TR-64, TR-66, TR-67, TR-69, TR-70, TR-71, TR-73, TR-74, TR-75, TR-76, TR-77, TR-78, TR-79, TR-80, TR-81, TR-82, TR-83, TR-84, TR-90.
FDR A2	Feeder A2 is fed from T-DYESS 1 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 350kcmils, 1/0 AWG, 2 AWG. Overhead cables are typically 2/0 Quail, 4/0 Penguin. Feeder A2 feeds the following locations: T-40A, T1-1, T1-1A, T1-2, T1-3, T1-4, T1-5, T1-6, T1-7, T1-8, T1-9, T1-10, T1-11, T1-12, T1-13, T1-14, T1-15, T1-16, T1-17, T1-18, T1-19, T1-20, T1-21, T1-22, T1-23, T1-24, T1-25, T1-26, T1-27, T1-28, T1-29, T1-30, T1-31, T1-32, T1-33, T1-34, T1-35, T1-36, T1-37, T1-38, T1-49, T5-1, T5-2, T5-3, T5-4, T5-5, T5-6, T5-7, T5-8, T95S1-1, T95S1-2, T95S1-3, T95S2-1, T95S2-2, T95S2-3, T95S2-4, T95S2-5, T95S2-6, T11902, T11905, T11913, T11955A, T11955B, T11959, TA10, TB1, TB2, TB3, TB4, TB5, TB6, TB7, TB8, TB9, TC1, TC2, TC3, TC4, TC5, TC6, TC7, TC8, TC9, TC10, TC11, TP-A2-L2-5, TP-C1-4.
FDR B1	Feeder B1 is fed from T-DYESS 2 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 1 AWG, 2/0 AWG, 2 AWG. Overhead cables are typically 2-6 Sparrow, 4/0 Penguin. Feeder B1 feeds the following locations: T-AIR2, T-AIR3, T-AIR4, T-FIRE1, T-FIRE2, T-NAOC, T-RAMP28, T4101, T4112, T4127, T4170A, T4170B, T4201, T4202, T4225, T4230, T9001, T9018, T9024, T9030, TP-B1-34, TP-B1-40, TP-B1-L3-1, TP-B1-L3-11, TP-B1-L5-2, TP4095, TP4222, TP6015, TP9018.
FDR B2	Feeder B2 is fed from T-DYESS 2 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 1 AWG, 4/0 AWG, 2 AWG. Overhead cables are typically 2-6 Sparrow, 4/0 Penguin. Feeder B2 feeds the following locations: T-BALL1, T-LT1, T6030A, T6030B, T6030C, T6030D, T6130, T6132, T6136A, T6136B, T6137, T6138A, T6138B, T6141, T7000A, T7000B, T7002, T7004A, T7004B, T7004C, T7004D, T7007A, T7007B, T7008A, T7008B, T7008C, T7008D, T7010, T7101, T7104, T7230, T7233, T7234, T7237, T7238, T8001, T8006, T8007, T8008, T8011, T8130A, T9045, T9198, T9304, T9305, TP-B2-9, TP-B2-35, TP-B2-55, TP-B2-L2-2, TP8014,
FDR B3	Feeder B3 is fed from T-DYESS 2 and uses underground and overhead distribution. Underground cables are typically 350kcmils, 4/0 AWG, 2 AWG. Overhead cables are typically 2/0 Quail, 4-6 Swan, 2-6 Sparrow, 4/0 Penguin. Feeder B3 feeds the following locations: T-FLOOD1, T-LT22, T-LT23, T-LT24, T-LT25, T-LT27, T-LT28, T-LT29, T-LT31, T6112A, T6113, T6115, T9097, T9109, T9114B, T9118, T9120, T9142, T9153A, T9153B, T9165, T9169, T9190, T9320, T9329, T9330, T9350, TP-B3-3, TP-B3-8, TP-B3-22, TP-B3-L2-3, TP-B3-L2-7, TP-B3-L2-27, TP-B3-L2-28, TP-B3-L2-36, TP-B3-L2-40, TP-B3-L2-41, TP-TRAILER2, TP9104.
FDR B4	Feeder B4 is fed from T-DYESS 2 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 1/0 AWG, 2/0 AWG, 4/0 AWG, 2 AWG. Overhead cables are typically 2/0 Quail, 4-6 Swan, 2-6 Sparrow, 4/0 Penguin. Feeder B4 feeds the following locations: T-BOMBPAD, T-LIFT2, T-LT2, T-LT3, T-LT4, T-LT12, T-SB4-010A, T-SB4-010B, T9110, T9112A, T9112B, T9121A, T9121B, T9201, T9203, T9219, T9220, T9222, T9223, T9243, T9265, TP-B4-8, TP-B4-83, TP-B4-89, TP-B4-97, TP-B4-107, TP-B4-L2-1, TP-B4-L2-9, TP9199, TP9206.
FDR C1	Feeder C1 is fed from T-DYESS 3 and uses underground and overhead distribution. Underground cables are typically 250kcmils. Overhead cables are typically 4/0 Penguin. Feeder C1 feeds the following locations: TP-C1-4
FDR C2	Feeder C2 is fed from T-DYESS 3 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 4/0 AWG, 2 AWG. Overhead cables are typically 2/0 Quail, 4/0

Feeder	Description
	Penguin. Feeder C2 feeds the following locations: T-LT5, T-LT6, T-LT7, T-LT8, T-LT9, T-LT10, T-LT11, T6117, T6119, T6122A, T6122B, T6123, T6125B, T6127A, T6127B, T6220, T6222, T6240, T7106A, T7106B, T7108, T7110, T7115, T7116, T7117, T7206, T7215, T7216, T7217, T7218A, T7218B, T7219A, T7220A, T7223, T7298, T7301, T7302, T7312, T7316A, T7316B, T7318A, T7318B, T7320, T7339, T7340, T7402, T7403, T7405, T7407, T7409, T7413, T7416, T7421, T8150, T8202A, T8202B, T8211, T8215, TP-C2-7, TP-C2-24, TP-C2-L1-8, TP-C2-L1-12, TP-C2-L1-22, TP6221.
FDR C3	Feeder C3 is fed from T-DYESS 3 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 4/0 AWG, 2 AWG, 1 AWG, 1/0 AWG. Overhead cables are typically 2-6 Sparrow, 4/0 Penguin. Feeder C3 feeds the following locations: T-RAMP9, T-RAMP11, T-RAMP13, T-RAMP15, T-RAMP30, T5110A, T5110B, T5111, T5112, T5114, T5115, T5130, T5138, T5160, T5160B, T5280, T8015, T8080A, T8080B, T8140, TP-C3-18A, TP-C3-18B, TP-LT1.
FDR C4	Feeder C4 is fed from T-DYESS 3 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 4/0 AWG, 2 AWG, 1 AWG, 2/0 AWG. Overhead cables are typically 2/0 Quail, 2-6 Sparrow, 4/0 Penguin, 4-6 Swan. Feeder C4 feeds the following locations: T-RAMP1, T-RAMP2, T-RAMP3, T-RAMP4, T-RAMP5, T-RAMP7, T-RAMP29, T5142, T5204A, T5204B, T5205, T5209, T5262, T5270, T8020, T8040A, T8040B, T8046, T8118, T8130B, T8131, TP-C4-23, TP-C4-L4-3, TP-C4-L4-6, TP-C4-L6-3, TP-TRAILER1, TP5206, TP5208, TP8037, TP8119, TP8120.
FDR C5	Feeder C5 is fed from T-DYESS 3 and uses underground and overhead distribution. Underground cables are typically 250kcmils, 4/0 AWG, 2 AWG, 2/0 AWG. Overhead cables are typically 2-6 Sparrow, 4/0 Penguin. Feeder C5 feeds the following locations: T-AIR 1, T-AIR7, T-AIR8, T-CASS1, T-CASS2, T-CASS3, T-CASS4, T-CASS5, T-LIFT1, T3239, T3245, T5212, T5224A, T5224B, T5225, T11741, T11751A, T11751B, T11751C, T11751D, T11751E, T11751F, TP-C5-15, TP-C5-17, TP-C5-27A, TP-C5-L1-6, TP5305.

4

POWER FLOW ANALYSIS

Section 4 provides the power flow analysis. Where applicable, the ability to cross-connect feeders without exceeding feeder ampacity limit are addressed in Section 5.

4.1 Purpose of Power Flow Analysis

A power flow study ensures that an electrical power system is fundamentally sound and capable of performing its design function. The principal objectives of the power flow analysis are:

- Determine system voltages under normal and abnormal operating modes. Confirm voltage drops throughout the system are within acceptable limits.
- Determine real and reactive power flow (current flow) throughout the system. Confirm that overload conditions do not exist.
- Evaluate system growth potential with respect to distribution capacity.

Section 1 provides additional background information about power flow studies. This section provides a summary of the EasyPower power flow analysis. Volume 2 Appendix J contains a complete report of the base case power flow analysis, including:

- The Transformer overload summary for the Primary Distribution Transformers.
- Line overload summary –Underground Cables and Overhead Lines.
- Power flow calculation output.

The EasyPower model is a model of the primary distribution system. With this model, the Base can generate future graphical and text outputs covering all locations in the system. The model can be used to assess the viability of future load additions or contingency line-ups. Text reports and on-screen presentation of power flow results can be customized to accommodate individual user preferences.

4.2 Viewing the Power Flow Analysis Results in EasyPower

The EasyPower models are provided in the enclosed DVD, with the name *CLIN01-Dyess AFB - Model-Final Report.dez*. A typical EasyPower power flow display is shown on Figure 4-1.

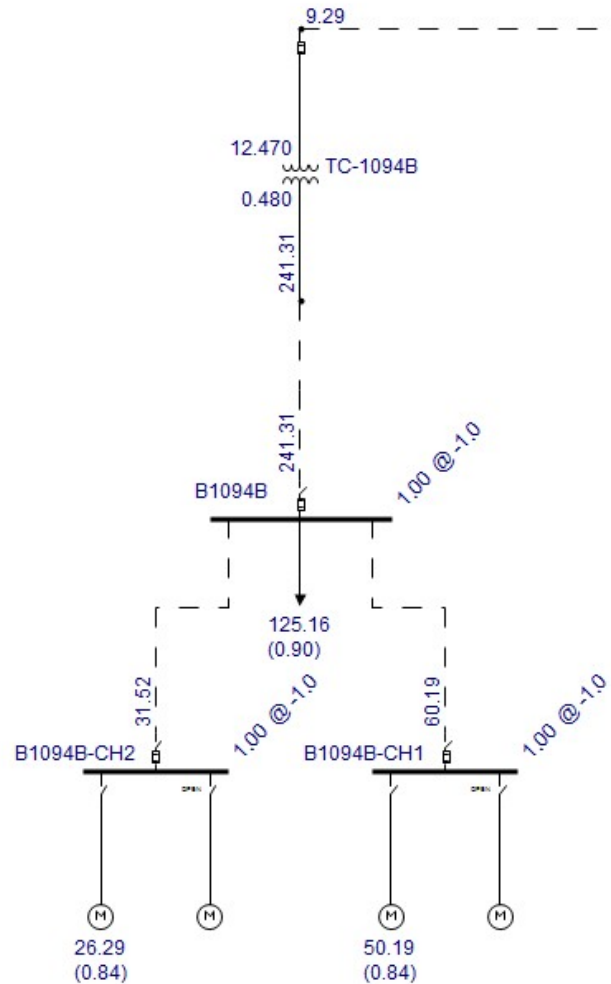


Figure 4-1
Typical EasyPower Power Flow Result

Referring to Figure 4-1, the interpretation of a typical EasyPower power flow display is as follows:

- Transformer TC-1094B designed for 12.47 kV on the primary and 480 volts on the secondary.
- The primary current flow into Transformer TC-1094B is 9.29 amperes.
- The secondary current flow out of Transformer TC-1094B is 241.31 amperes.
- The voltage magnitude on the secondary of Transformer TC-1094B is 1.00 per unit, corresponding to 480 volts ($1.00 \times 480 = 480$).
- The total load on Transformer TC-1094B is 125.16 kVA at a 0.90 power factor plus two chillers operating at 26.29 and 50.19 kVA at a 0.84 power factor.

The power flow results are best viewed within EasyPower. As part of this project, EasyPower training has been provided to Dyess AFB personnel to facilitate this preferred method of viewing analysis results. A tabular printout of the base case is provided in Appendix J.

4.3 Electrical Power Consumption and Demand

As part of the model development for the power flow analysis, representative load estimates are required throughout the power system.

The process implemented for determination of modeled peak load is as follows:

- 1- TWN meters instantaneous load at transformer secondary and/or service entrance as a reference point for peak load alignment.
- 2- Historic Peak Load assessments, facility specific peak load studies (past or future) and prior model are referenced.
- 3- Facility peak load is estimated based on the data available with consideration for granularity of downstream data. (It is noted: Instantaneous measurements may not be representative of peak load but set a lower limit of load at said metered point)
- 4- Estimated peak load determination is derived based on available data, measurement limits, observation of identified changes over time, future projects and facility expansion relative to data utilized.
- 5- End loads are scaled based on peak load estimates adjusted for known loads (i.e., motors >50hp and specific identifiable loads), resulting in a balanced peak load profile relative to the facility's anticipated peak.

4.3.1 Power Demand Data – Total Base

Instantaneous measurements were taken at multiple accessible locations in support of the power flow analysis. Table 4-1 represents the locations and instantaneous measurements recorded as part of the field data collection process.

Table 4-1
Instantaneous Measurements and Estimated Peak Amps

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T4101	8.52	9.93	11.15	496.20	494.63	496.06	11.15	46.50%	27.80	1.62
T4112	28.03	33.64	3.43	247.59	123.64	123.68	33.64	96.10%	35.27	33.31

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T4170A	6.61	14.96	12.82	214.29	214.21	214.54	14.96	-99.60%	10.03	1.51
T4201	11.18	13.56	3.1	248.8	124.29	124.24	13.56	-84.80%	11.45	38.73
T4202	33.1	19.74	20.9	113.89	121.53	215.22	33.1	86.80%	15.43	2.31
T4216	300.41	306.16	289.11	493.15	491.56	493.43	306.16	89.60%	5.87	1.70
T4218	16.49	25.16	21.71	214.59	213.56	213.95	25.16	-99.60%	9.96	1.61
T4225	72.67	75.2	77.41	468.15	465.94	466.81	77.41	57.30%	3.96	1.79
T4300	37.73	39.23	34.02	493.68	493.01	493.03	39.23	86.80%	19.47	1.94
T4311	32.66	41.95	36.35	496.71	496.23	495.91	41.95	65.70%	10.46	1.11
T4312	23.75	12.88	21.52	494.93	492.33	492.94	23.75	88.70%	17.83	1.53
T4315	9.71	12.79	14	480.7	480.25	480.99	14	89.70%	18.95	1.75
T4316A	3.15	3.17	3.15	494.06	493.62	494.59	3.17	-83.10%	2.91	1.78
T5001	6.13	5.86	3.16	214.97	215.14	215.14	6.13	99.20%	14.25	1.42
T5001B	3.12	3.22	3.14	496.88	495.99	497.48	3.22	-99.90%	0.00	1.04
T5003A	31.01	17.85	28.45	214	213.72	213.9	31.01	-97.30%	21.12	1.83
T5003B	6.65	7.01	6.75	495.66	493.81	494.68	7.01	98.90%	93.24	1.31
T5004A	28.52	29.32	33.18	494.32	493.46	494.05	33.18	22.70%	41.91	1.45

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T5005A	251	256.74	240.19	495.19	492.87	493.43	256.74	95.00%	16.29	1.65
T5005B	190.82	159.99	188.27	494.58	492.66	492.71	190.82	76.30%	3.07	1.29
T5013	120.8	64.62	123.14	492.71	490.39	490.45	123.14	62.90%	10.99	1.79
T5014	26.55	29.59	32.38	214.25	213.13	213.97	32.38	-100.00%	14.55	1.65
T5015	76.15	100.74	86.06	213.72	213.37	213.68	100.74	99.80%	15.73	1.53
T5016	31.48	32.94	36.42	213.85	213.61	213.7	36.42	97.70%	12.05	1.41
T5020	172.62	183.16	175.73	471.09	469.16	469.49	183.16	90.80%	6.84	0.85
T5108B	26.46	27.19	28.31	470.03	468.55	470.08	28.31	84.90%	21.02	1.72
T5110A	74.31	70.89	85.17	485.3	483.42	483.38	85.17	82.60%	4.87	2.78
T5110B	19.42	23.14	27.25	486.01	483.65	483.79	27.25	94.30%	9.56	2.47
T5111	45.65	54.30	47.29	496.98	495.4	495.14	54.3	88.50%	23.75	2.59
T5112	26.02	27.71	22.13	499.4	498.67	499.65	27.71	-99.90%	10.68	1.56
T5114	28.71	24.47	26.89	210.71	210.09	211.12	28.71	99.50%	52.09	1.29
T5115	17.85	5.24	5.73	216.99	215.88	216.36	17.85	98.50%	27.27	1.30
T5130	80.59	65.21	53.49	215.2	215.09	215.66	80.59	96.60%	2.65	1.99
T5138	18.61	19.60	21.07	475.88	474.08	475.8	21.07	97.40%	4.49	1.86

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T5142	11.44	9.79	11.33	494.04	493.29	493.36	11.44	98.70%	8.04	1.23
T5160	6.31	3.18	3.12	216.14	215.09	215.07	6.31	-99.10%	5.40	2.41
T5204A	5.46	5.44	7.06	480.25	480.58	479.56	7.06	71.20%	24.59	1.87
T5204B	22.71	22.57	21.43	489.75	489.56	490.38	22.71	84.30%	18.97	2.10
T5205	3.21	3.11	3.09	246.29	123	123.02	3.21	38.90%	15.32	33.91
T5209	15.76	14.61	3.6	213.83	212.96	214.21	15.76	-99.70%	6.61	1.84
T5212	6.85	10.67	9.67	493.23	493.06	493.16	10.67	78.40%	28.33	0.98
T5224B	21.06	17.62	17.99	494.08	492.08	492.83	21.06	51.50%	18.01	1.10
T5225	158.08	152.54	161.15	492.46	492.65	493.25	161.15	90.30%	7.46	1.96
T5270	3.18	3.17	3.54	213.14	213.16	213.29	3.54	50.00%	22.30	2.24
T5280	23.64	10.16	16.53	216.52	216.57	216.87	23.64	100.00%	11.74	1.68
T6030C	48.82	25.22	3.14	217.34	216.79	216.18	48.82	-99.70%	3.96	2.18
T6030D	96.47	99.37	98.95	218.59	217.16	218.15	99.37	-53.80%	28.96	2.71
T6112A	38.62	38.41	43.1	217.34	216.21	216.68	43.1	99.70%	16.22	1.66
T6113	108.25	158.25	167.29	216.01	215.91	216.25	167.29	97.90%	10.52	1.57
T6115	4.1	4.05	8.71	216.71	216.88	216.81	8.71	-73.90%	101.26	1.64

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T6117	96.14	79.45	77.51	215.84	215.16	216.09	96.14	96.20%	5.42	1.59
T6122A	6.67	6.51	6.18	499.26	496.96	499.47	6.67	98.50%	102.30	1.85
T6122B	15.33	17.83	21.14	216.21	215.04	216.13	21.14	99.70%	21.16	1.94
T6123	4.82	15.93	7.7	216.69	215.13	215.88	15.93	99.50%	41.68	1.76
T6125B	133.56	124.69	145.54	216.42	215.17	215.46	145.54	98.70%	15.22	1.81
T6127A	57.14	38.88	75.69	216.35	214.84	215.4	75.69	98.10%	16.85	2.02
T6127B	3.13	3.13	3.22	499.57	496.39	497.92	3.22	-100.00%	0.00	1.78
T6130	21.53	25.60	19.28	486.65	485.89	487.83	25.6	-34.70%	9.88	2.22
T6132	127.7	144.87	124.95	498.88	495.63	497.45	144.87	77.30%	5.13	2.14
T6136A	109.31	107.71	99.25	216.14	216.26	216.09	109.31	97.90%	12.39	2.16
T6136B	3.1	3.27	3.36	498.38	499.01	500.15	3.36	-99.20%	22.70	2.07
T6137	122.63	97.12	87.28	215.94	216.16	215.88	122.63	87.80%	7.38	1.90
T6138B	89.74	79.50	80.44	216.76	216.44	215.94	89.74	99.00%	19.19	2.42
T6141	7.83	3.35	3.35	216.99	216.04	217.03	7.83	-98.70%	53.99	2.44
T6220	73.64	66.32	73.82	214.35	214.26	213.98	73.82	99.30%	6.18	2.36
T6222	11.69	13.85	19.57	215.82	215.39	214.81	19.57	-98.60%	15.84	2.61

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T7000A	50.52	39.25	42.62	497.58	496.17	498.13	50.52	96.50%	9.34	1.59
T7000B	53.12	41.17	44.62	497.18	495.67	497.44	53.12	73.60%	7.58	1.55
T7002	32	39.23	36.52	497.61	494.63	496.76	39.23	71.70%	7.25	1.7
T7004A	46.05	38.79	38.75	216.21	215.13	216.1	46.05	93.20%	20.77	1.91
T7004B	9.47	3.16	6.26	216.19	214.98	215.89	9.47	-99.90%	26.89	1.86
T7004C	75.7	70.64	59.8	493.4	492.9	494.44	75.7	84.00%	10.03	1.84
T7004D	3.44	3.4	3.03	498.54	498.76	497.83	3.44	5.50%	20.5	1.55
T7007A	42.46	35.29	33.41	215.83	216.13	215.93	42.46	96.90%	31.84	1.24
T7007B	37.46	79.1	77.63	499.05	496.19	497.86	79.1	61.80%	6.02	1.56
T7008A	73.23	89.85	71.56	215.86	215.56	216.62	89.85	94.80%	6.64	1.48
T7008B	3.09	3.17	3.25	498.81	499.14	500.64	3.25	-79.30%	0	1.14
T7008C	194.86	176.77	192.66	215.14	215.02	215.78	194.86	75.50%	5.38	1.2
T7008D	11.28	11.13	3.21	500.02	499.58	501.83	11.28	99.60%	3.8	1.32
T7010	17.33	13.63	5.78	216.35	215.68	215.72	17.33	37.20%	3.92	1.21
T7040	40.43	44.24	49.15	493.5	492.81	494.05	49.15	81.70%	5.01	1.29
T7101	9.04	3.14	3.43	216	215.6	216.26	9.04	93.20%	78.3	1.58

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T7104	129.32	134.27	128.3	500.91	497.92	499.43	134.27	83.70%	8.77	2.34
T7106A	40.37	48.05	35.23	215.53	214.41	215.31	48.05	98.60%	26.85	2.52
T7106B	58.13	54.46	63.16	215.41	214.29	215.12	63.16	96.50%	18.2	2.58
T7115	43.4	44.32	32.3	214.25	214.47	214.62	214.62	93.60%	9.9	2.79
T7206	215.22	214.56	215.31	52.76	45.95	49.56	215.31	66.30%	4.35	1.76
T7215	27.17	16.87	17.76	215.72	215.09	214.92	27.17	-100.00%	20.25	2.82
T7216	3.95	7.39	3.45	214.87	214.93	215.18	7.39	-99.50%	25.3	2.63
T7217	3.27	14.28	3.67	215	214.42	215.46	14.28	85.00%	36.97	2.51
T7219A	56.78	64.24	51.07	215.26	215.11	215.05	64.24	98.60%	16.13	2.62
T7220A	47.28	38.29	45.62	216.03	214.86	215.12	47.28	99.40%	13.38	2.54
T7223	52.94	53.86	49.48	484.3	484.26	484.9	53.86	98.10%	58.09	2.59
T7233	135.58	81.65	71.34	215.54	215.71	215.58	135.58	99.80%	20.7	1.94
T7234	45.52	43.31	41.29	216.41	215.34	215.66	45.52	88.70%	7.73	1.77
T7237	86.28	78.19	73.74	216.33	215.47	215.36	86.28	99.30%	14.3	1.99
T7238	18.8	20.45	17.05	216.1	215.73	216.55	20.45	82.10%	5.22	1.68
T7298	15.46	26.97	23.5	215.13	214.38	215.14	26.97	-99.80%	10.9	2.01

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T7302	9.17	6.79	6.72	214	214.57	214.72	9.17	99.60%	7.91	2.75
T7316A	22.66	22.96	26.78	496.04	494.38	495.68	26.78	99.40%	12.59	1.88
T7316B	15.44	13.32	13.22	214.65	213.93	214.6	15.44	97.50%	33.25	1.61
T7318A	81.38	73.1	72.92	215.73	214.7	214.74	81.38	-99.90%	8.68	1.89
T7318B	6.62	6.91	3.11	248.33	124.01	124.05	6.91	-99.50%	9.03	38.4
T7320	68.39	71.38	66.7	497.26	496.46	495.46	71.38	88.40%	9.75	1.68
T7339	179.36	169.03	166.69	496.37	494.1	494.58	179.36	99.50%	7.72	2.34
T7340	268.61	245.03	245.37	494.52	491.69	492.18	268.61	87.20%	3.42	2.27
T7402	158.33	141.01	146.94	214.35	214.73	214.11	158.33	100.00%	18.54	2.93
T7403	22.12	3.45	7.39	214.61	215.03	214.03	22.12	85.30%	25.5	2.34
T7405	27.2	17.44	37.44	215.85	214.64	214.9	37.44	-98.80%	41.91	2.34
T7407	66.42	65.85	58.95	214.03	212.91	213.81	66.42	98.50%	35.46	2.68
T7409	8.79	5.67	4.32	214.9	215	214.82	8.79	-98.20%	34.6	2.38
T7421	34.69	35	45.81	214.42	214.23	213.77	45.81	100.00%	15.71	2.36
T8001	25.79	10.77	27.5	216.69	215.4	215.71	27.5	97.20%	4.15	1.32
T8006	49.39	43.55	48.08	215.21	214.92	215.68	49.39	-98.60%	31.98	2.18

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T8007	24.81	31.26	31.9	499.82	496.51	498.63	31.9	74.60%	13.08	1.62
T8008	91.99	97.14	80.64	214.64	213.54	214.33	97.14	98.60%	21.86	1.93
T8011	16.46	15.37	14.78	216.12	215.12	215.7	16.46	97.30%	16.85	2.13
T8013	28.33	29.74	20.4	214.12	213.34	213.65	29.74	98.70%	7.4	1.56
T8015	88.46	98.81	87.38	215.79	215.23	214.88	98.81	96.30%	7.16	2.04
T8020	5.93	14.8	6.93	213.42	212.9	213.23	14.8	-99.80%	20.19	1.29
T8030	28.59	19.32	21.28	209.18	208.84	209.61	28.59	-91.70%	18.28	1.72
T8031	112.57	82.92	103.22	214.69	213.74	214.61	112.57	-99.70%	30.47	1.83
T8032	9.81	36.87	24.78	213.71	213.3	213.92	36.87	-96.20%	35.9	1.72
T8040A	113.07	110.36	112.85	489.54	488.24	489.6	113.07	78.30%	3.41	1.54
T8040B	38.65	38.04	29.26	218.39	217.94	217.77	38.65	98.80%	26.51	1.97
T8080A	6.4	7.95	13.06	215.53	215.01	215.87	13.06	-97.50%	32.9	2.42
T8080B	3.16	3.13	3.15	215.68	214.56	215.47	3.16	43.00%	0	2
T8130A	6.37	6.58	8.11	497.89	495.39	496.74	8.11	36.50%	24.04	1.63
T8130B	28.78	16.02	15.57	208.47	207.79	207.99	28.78	93.60%	10.42	1.65
T8131	11.07	11.93	15.88	481.36	479.46	480.09	15.88	26.30%	26.66	1.78

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T8140	49.3	42.36	48.5	501.41	501.67	501.37	49.3	92.00%	22.01	2.47
T8150	22.18	31.62	39.15	485.59	483.06	482.92	39.15	70.20%	18.63	1.89
T8202A	40.39	27.29	20.2	216.46	215.01	215.94	40.39	-99.10%	24	1.8
T8202B	44.18	39.58	38.56	498.57	495.36	497.28	44.18	75.90%	5.59	1.73
T8211	78.32	77.28	76.51	215.7	214.52	215.3	78.32	75.40%	14.42	2.13
T8215	6.32	6.37	7.2	497.66	498.17	497.78	7.2	39.60%	17.84	2.2
T9001	75.67	66.9	70.99	215.03	214.34	214.88	75.67	96.50%	22.44	1.53
T9045	12.9	30.27	37.5	216.39	214.61	214.96	37.5	-98.00%	10.2	1.77
T9097	22.22	19.1	25.66	204.29	203.43	203.87	25.66	-99.80%	70.31	2.21
T9109	3.35	4.3	4.43	215.32	214.41	214.89	4.43	99.50%	58.81	1.66
T9110	32.65	18.74	29.88	493.89	493.38	492.93	32.65	98.60%	22.13	1.11
T9112A	32.87	22.77	23.4	484.06	483.3	484.84	32.87	92.40%	38.8	1.52
T9112B	33.02	32.13	33.04	496.48	494.42	496.74	33.04	74.10%	10.96	1.5
T9120	7.41	19.57	3.21	249	124.34	124.39	19.57	-99.90%	15.6	37.99
T9121A	32.41	46.58	31.02	215.26	214.53	214.54	46.58	85.90%	13.62	1.71
T9121B	3.28	3.22	3.25	490.96	492.15	492.01	3.28	52.00%	1.38	1.81

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T9153A	30.85	28.09	19.06	485.58	484.07	483.23	30.85	93.90%	12.96	1.5
T9190	11.84	26.2	18.24	210.63	209.57	210.18	26.2	100.00%	9.04	1.8
T9198	31.94	34.29	26.17	475.09	473.65	473.43	34.29	89.00%	9.93	1.52
T9201	365.76	338.35	347.57	495.96	495.98	496.04	365.76	98.80%	12.73	2.66
T9203	48.55	43.81	37.01	214.43	214.12	214.96	48.55	97.00%	11.22	2.05
T9219	196.7	108.83	6.58	248.26	124.11	123.88	196.7	99.90%	9.6	11.57
T9220	6.46	10.26	5.92	215.59	214.78	214.74	10.26	-98.00%	36.02	2.05
T9222	8.88	10.9	3.2	248.83	124.27	124.29	10.9	55.20%	3.49	37.14
T9304	15.46	10.45	14.07	486.89	484.85	486.91	15.46	82.30%	15.99	1.59
T9305	3.83	3.16	3.15	216.21	215.76	216.43	3.83	99.50%	13.19	2.27
T9329	9.13	5.95	7.68	499.5	498.15	498.91	9.13	83.50%	16.53	2.36
T9330	81.51	88.58	84.4	215.4	214.6	215.42	88.58	100.00%	6.94	1.53
T9350	3.24	3.15	3.18	474.04	471.9	472.39	3.24	-99.10%	2.14	1.41
T11751A	31.74	44.43	32.78	213.9	213.82	214.01	44.43	82.90%	6.78	1.94
T11902	51.51	52.6	51.11	490.97	487.97	486.61	52.6	73.60%	4.02	1.99
T11913	7.03	6.57	3.84	216.95	217.31	216.34	7.03	84.30%	22.93	1.87

Metered Location	AMPS			VOLTS (L-L)			Estimated Peak Amps	Power Factor %	Total Current Harmonic Distortion	Total Voltage Harmonic Distortion
	Phase			Phase						
	A	B	C	A/B	B/C	C/A				
T11955A	25.84	24.6	25.76	217.39	217.89	217.74	25.84	87.50%	10.28	2.04
TPC4-L4-6	30.41	3.17	3.18	245.96	123.14	122.56	30.41	100.00%	1.91	6.77

*Note: Highlighted Transformers show a voltage variation of greater than 3%. Some transformers had unexpected THD values likely due to faulty measurements and/or low loading at time of measurement.

The power flow analysis is performed based on estimated peak demand for the facility. For this study, the estimated peak demand for modeling purposes was based on historical data. The resulting peak demand is 13 MVA. The individual estimated peak demand is shown in Table 4-1 and compared with the instantaneous measurements. This peak demand forms the basis for the analysis of the existing system.

4.3.2 Feeder Configuration for Reference Power Flow Analysis

The power flow analysis is based on the system operating configuration as shown in the electrical one-line drawings. Normally open points between feeders are maintained open in the EasyPower model.

4.4 Summary of Power Flow Analysis Results

4.4.1 Normal Operation Results

The term normal operation means that the Utility is in service and operating in the normal lineup shown on the system one-line drawings. Appendix J provides the detailed power flow results for this configuration.

4.4.2 Abnormal Operation

The Installation provided no abnormal scenarios that were to be analyzed for any transformer loading issues.

4.4.3 Equipment / Cable Loading

There are three (3) cables that are overloaded (C-B-86, C-BP4317A SE1B, C-B11955B) based on the information collected during data collection and the EasyPower power flow report. There were no transformers in violation of being overloaded and only one warning (T9121B).

4.4.4 System Voltage and Power Factor Variation

Power factor data is collected via instantaneous spot measurements at the secondary transformer level. It is expected that power factor levels will fluctuate with various loading equipment and

amount of load connected to the system. As such, without further study consisting of constant metering over a set period, TWN provides power factor results for informational purposes only.

Twenty-Nine (29) of the specified load points resulting in a voltage variation of more than 3% are shown in Table 4-2. However, due to the extensive number of items, the full list is provided in Appendix J - Power Flow Summary Report.

Table 4-2
Base Case - Utility - Voltage Variation > 3%

Equipment Busses	Base KV	KV	Vpu	%	Identified Considerations
B-B3-L2-27 IN	0.208	0.222	1.07	6.7	
B-B3-L2-27 OUT	0.208	0.222	1.07	6.7	
B-BALL1 IN	0.48	0.514	1.07	7.1	
B-BALL1 OUT	0.48	0.514	1.07	7.1	
B-BOMBPAD IN	0.208	0.223	1.07	7.2	
B-BOMBPAD OUT	0.208	0.223	1.07	7.2	
B-EG1	0.48	0.518	1.078	7.9	
B-FIRE1 IN	0.48	0.516	1.075	7.5	
B-FIRE1 OUT	0.48	0.516	1.075	7.5	
B-FIRE2 SE1 IN	0.208	0.224	1.075	7.7	
B-FIRE2 SE1 OUT	0.208	0.224	1.075	7.7	
B-FIRE2 SE2 IN	0.208	0.224	1.075	7.7	
B-FIRE2 SE2 OUT	0.208	0.224	1.075	7.7	
B-LIFT1 IN	0.48	0.506	1.054	5.4	
B-LIFT1 OUT	0.48	0.506	1.054	5.4	
B-LT22 SE1 IN	0.48	0.512	1.066	6.7	
B-LT22 SE1 OUT	0.48	0.512	1.066	6.7	
B-LT22 SE2 IN	0.48	0.512	1.066	6.7	
B-LT22 SE2 OUT	0.48	0.512	1.066	6.7	
B-LT23 SE1 IN	0.48	0.513	1.068	6.9	
B-LT23 SE1 OUT	0.48	0.513	1.068	6.9	
B-LT24 IN	0.48	0.502	1.046	4.6	
B-LT28 SE1 IN	0.48	0.495	1.031	3.1	
B-LT28 SE1 OUT	0.48	0.495	1.031	3.1	
B-LT29 SE1 IN	0.48	0.507	1.055	5.6	
B-LT29 SE1 OUT	0.48	0.507	1.055	5.6	
B-LT31 IN	0.48	0.498	1.037	3.8	
B-M7008D (FP)	0.48	0.511	1.064	6.5	
B-RAMP7 IN	0.208	0.22	1.057	5.8	

Table 4-3 represents the instantaneous power factor at the time of data collection. It is recognized the measured values may not be representative of all operating conditions.

Table 4-3
Base Case - Utility - Power Factor < 0.9

Electrical Equipment	Phase	Amps	Power Factor (%)
T4201	1-Phase	9.28	-84.80%
T4316A	3-Phase	3.16	-83.10%
T7008B	3-Phase	3.17	-79.30%
T6115	3-Phase	5.62	-73.90%
T6030D	3-Phase	98.26	-53.80%
T6130	3-Phase	22.14	-34.70%
T7004D	3-Phase	3.29	5.50%
T5004A	3-Phase	30.34	22.70%
T8131	3-Phase	12.96	26.30%
T8130A	3-Phase	7.02	36.50%
T7010	3-Phase	12.25	37.20%
T5205	1-Phase	3.14	38.90%
T8215	3-Phase	6.63	39.60%
T8080B	3-Phase	3.15	43.00%
T4101	3-Phase	9.87	46.50%
T5270	3-Phase	3.30	50.00%
T5224B	3-Phase	18.89	51.50%
T9121B	3-Phase	3.25	52.00%
T9222	1-Phase	7.66	55.20%
T4225	3-Phase	75.09	57.30%
T7007B	3-Phase	64.73	61.80%
T5013	3-Phase	102.85	62.90%
T4311	3-Phase	36.99	65.70%
T7206	3-Phase	215.03	66.30%
T8150	3-Phase	30.98	70.20%
T5204A	3-Phase	5.99	71.20%
T7002	3-Phase	35.92	71.70%
T7000B	3-Phase	46.30	73.60%
T11902	3-Phase	51.74	73.60%
T9112B	3-Phase	32.73	74.10%
T8007	3-Phase	29.32	74.60%
T8211	3-Phase	77.37	75.40%
T7008C	3-Phase	188.10	75.50%
T8202B	3-Phase	40.77	75.90%

Electrical Equipment	Phase	Amps	Power Factor (%)
T5005B	3-Phase	179.69	76.30%
T6132	3-Phase	132.51	77.30%
T8040A	3-Phase	112.09	78.30%
T5212	3-Phase	9.06	78.40%
T7040	3-Phase	44.61	81.70%
T7238	3-Phase	18.77	82.10%
T9304	3-Phase	13.33	82.30%
T5110A	3-Phase	76.79	82.60%
T11751A	3-Phase	36.32	82.90%
T9329	3-Phase	7.59	83.50%
T7104	3-Phase	130.63	83.70%
T7004C	3-Phase	68.71	84.00%
T5204B	3-Phase	22.24	84.30%
T11913	3-Phase	5.81	84.30%
T5108B	3-Phase	27.32	84.90%
T7217	3-Phase	7.07	85.00%
T7403	3-Phase	10.99	85.30%
T9121A	3-Phase	36.67	85.90%
T4202	3-Phase	24.58	86.80%
T4300	3-Phase	36.99	86.80%
T7340	3-Phase	253.00	87.20%
T11955A	3-Phase	25.40	87.50%
T6137	3-Phase	102.34	87.80%
T7320	3-Phase	68.82	88.40%
T5111	3-Phase	49.08	88.50%
T4312	3-Phase	19.38	88.70%
T7234	3-Phase	43.37	88.70%
T9198	3-Phase	30.80	89.00%
T4216	3-Phase	298.56	89.60%
T4315	3-Phase	12.17	89.70%

4.4.5 Motor Starting Summary

A motor starting study is a specific type of power flow study. The objective of a motor starting study is to confirm that the inrush current associated with starting a large motor does not cause voltage at the motor's terminals to drop below a level that prevents proper motor start. The study also checks whether the predicted voltage drop due to starting a motor is significant enough to affect other loads.

A motor starting study is performed by conducting a power flow analysis with the motor of interest modeled in a start condition. The power flow analysis results then provide predicted voltages under

the postulated motor start conditions. The voltages are compared to the typical limits established by a motor manufacturer to confirm acceptability.

Zero (0) of the twenty-four (24) motors have a voltage drop greater than 20% during motor starting.

Table 4-4
Base Case - Utility – Motor Starting

Motor (starting)	HP	Greater than 5% upstream bus voltage drop	Percent Voltage Change
M5001B-1	400	N	-4.38%
M5001B-2	400	N	-4.38%
M5001B-3	400	N	-4.38%
M5112 (AFF PUMP1)	50	N	3.33%
M5112 (AFF PUMP2)	50	N	3.33%
M5112 (CHILLER)	150	N	1.04%
M5160B-1	400	Y	-5.42%
M5160B-2	400	Y	-5.42%
M5160B-3	400	Y	-5.42%
M5212-1 (#9)	125	N	-4.79%
M5212-2 (#10)	125	N	-4.79%
M5212-3 (#11)	125	N	-4.79%
M5212-4 (#12)	125	N	-4.79%
M5212-5 (#13)	125	N	-4.58%
M5225 (FP)	100	N	0.42%
M6130-CH1	175	N	-3.96%
M6130-CH2	175	N	-4.58%
M7000A-CH2A	93	N	0.42%
M7000A-CH2B	93	N	-0.208%
M7004D (FP)	125	Y	-12.08%
M7008D (FP)	75	N	0.42%
M7223-CH1	250	Y	-11.25%
M7223-CH2	250	Y	-11.25%
M9121B (FP)	150	Y	-19.38%

4.4.6 Cold-Load Pickup.

The objective of the Cold-Load Pickup study is to assess the ability of energizing a distribution feeder. The study considers transformers inrush-magnetization and starting of all motors by feeder. EasyPower standard modeling parameters were used to represent the effects of transformer inrush and potential impacts relative to protection settings. Motor starting was accomplished through the EasyPower tools under the assumption of all motors starting simultaneously. As a note, it is recognized that the estimates for motor starting are worst case and may not be representative of real-world conditions.

Table 4-5 shows the results of the impacts associated with inrush and simultaneous motor starting for each feeder.

Table 4-5
Base Case - Utility – Cold-Load Pickup

Feeders	Transformer Inrush		Simultaneous Motor Starting		
	Total Amps	Inst Pickup (Amps)	Feeder Amps	Pickup (Amps)	Volts (kV)
FDR A1	2,050	N/A	N/A	0.3 (360A)	N/A
FDR A2 + FDR C1	3,721.52	N/A	N/A	0.3 (360A)	N/A
FDR B1 + FDR C5 + FDR C4	14,266	12 (1662.77A)	435.65	1.25 (173.205A)	12.47
FDR B2 + FDR C3	10,708	15 (2078.46A)	506.50	1.25 (173.205A)	12.47
FDR B3 + FDR C2	7,840	15 (2078.46A)	154.74	1.25 (173.205A)	12.47
FDR B4	1,948	10 (1385.64A)	51.49	1.25 (173.205A)	12.47

Note 1: Feeders A1 and A2 have no Instantaneous pick-up.

Note 2: Feeder A1, A2, B1, B3, and C1 do not have motors over 50HP.

Given the current relay settings, Feeder B1 (C4 and C5), Feeder B2 (C3), Feeder B3 (C2), and Feeder B4 are unable to perform transformer cold load pick-up when carrying Charlie Feeder loads. Feeder B1 (C4 and C5), and Feeder B2 (C3) will also be unable to perform a full simultaneous motor start. A plan should be implemented to start these motors incrementally to avoid any issues.

Given the current relay settings, when Bravo and Charlie are feeding their respective loads without cross-connections, FDR B1, FDR B2, FDR B4, FDR C2, FDR C3, and FDR C4 cannot perform transformer cold load pick-up. It is recommended to start transformers in small groups rather than all at once to manage cold load pick-up effectively. Additionally, FDR B2 cannot perform simultaneous motor starting

We recommend that, instead of starting all transformers simultaneously on a given feeder/feeders, a portion of them should be started at a time. This procedure should be applied to motor starting as well. Please note that if the base opts to modify the relay settings to enable a full cold-load transformer inrush or simultaneous motor starting for these feeders, this will reduce the protection on these feeders and increase the arc flash incident energy throughout them. Should this be the desired course of action, it may be advisable to change the curve setting in these relays from U3, US Very Inverse to U2, US Inverse.

5

SYSTEM CROSS-CONNECT CAPABILITY

5.1 System Cross-Connect Capability

The term cross-connect is defined as: a scenario where one feeder assumes the load of another feeder, either partially or entirely, in addition to its own load. Cross-connections may be necessary under any of the following conditions:

- Upon loss of a single feeder due to feeder conductor damage.
- To take equipment out of service for maintenance or repair.
- While upgrading a feeder or replacing an underground distribution cable.

5.2 Analysis Limitations and Cross-Tie Considerations

Whenever a system cross-connect is considered, the EasyPower model is used for review. Loads in the model can be adjusted for seasonal variations to reflect currently measured loading. With this approach, the EasyPower model can provide a cross-connect prediction capability for a specific distribution system configuration.

The availability of emergency generators for individual facilities are not considered as part of this cross-connect capability evaluation. This evaluation only applies to the capabilities of the primary distribution system, with all normal loads connected.

5.3 Cross-Connection Modeling Approach

The following represents the approach to determine the capability of the systems cross-connections.

Cross-Connection capability requirements:

- Source Feeder cables support the load within acceptable limits.
- Cross-Connect cables support the load within acceptable limits.
- Protection Equipment pickups are not exceeded in the cross-connect configuration.

Figure 5-1 is a representative example for a typical configuration of a system with an available cross-connect.

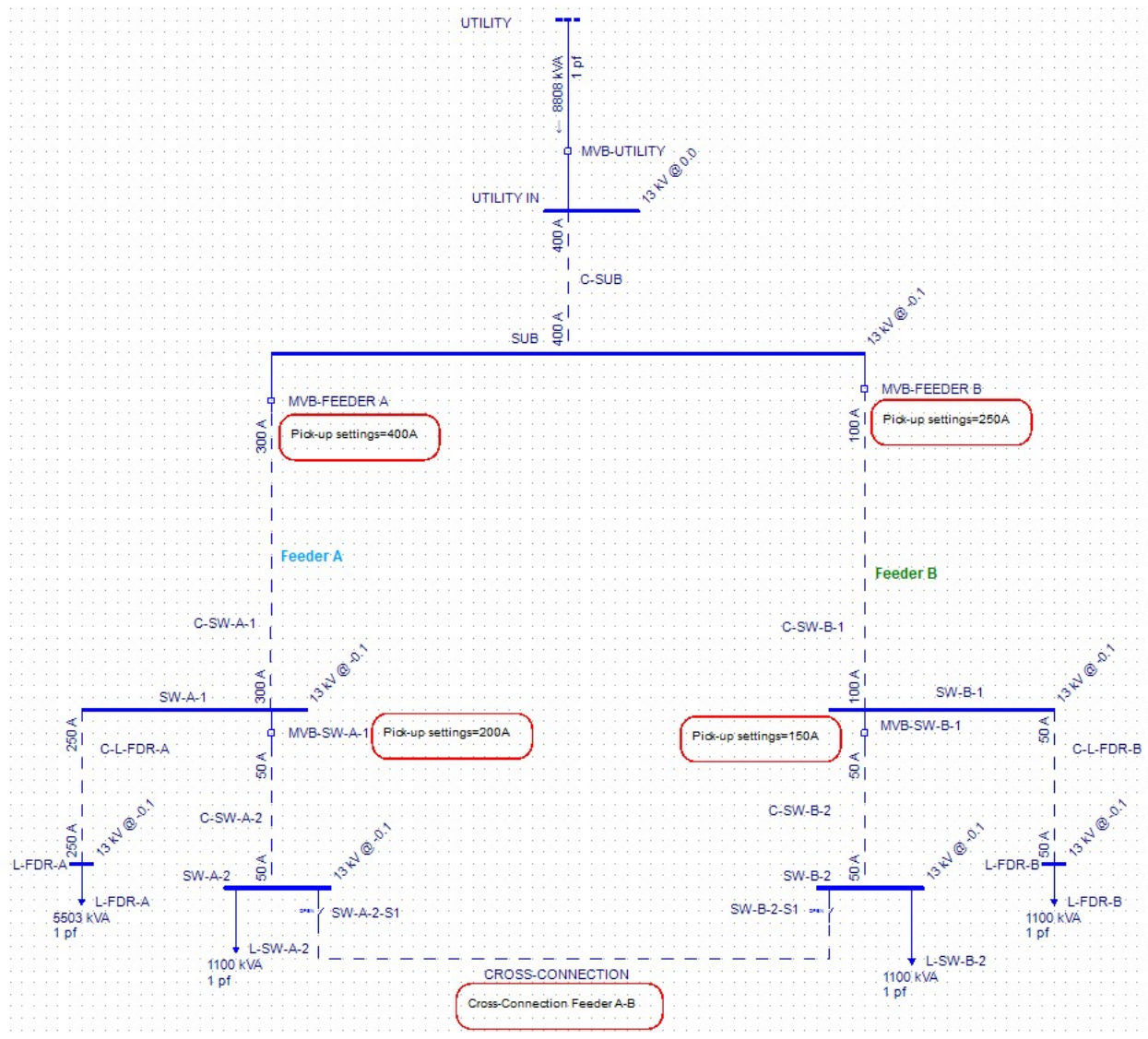


Figure 5-1
Normal Configuration

In the event Feeder B is lost, the cross-connection between A and B would be closed to allow Feeder A to serve Feeder B. Figure 5-2 shows that the additional load to Feeder A can be supported making this a viable cross-connection for Feeder A to serve Feeder B.

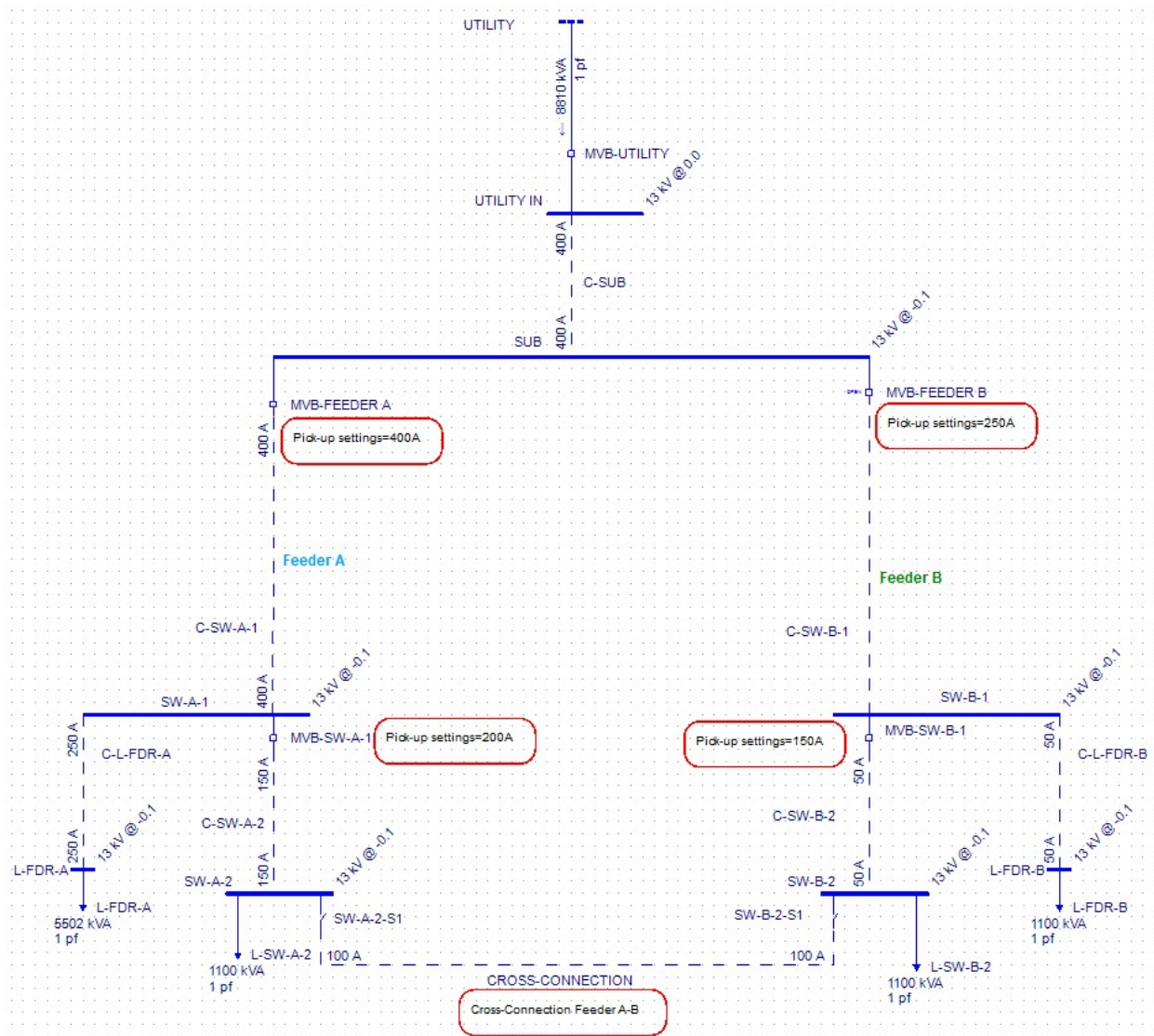


Figure 5-2
Feeder A serving B

In the case where Feeder A is lost, the cross-connection between A and B would be closed to allow Feeder B to serve Feeder A. This is shown in Figure 5-3.

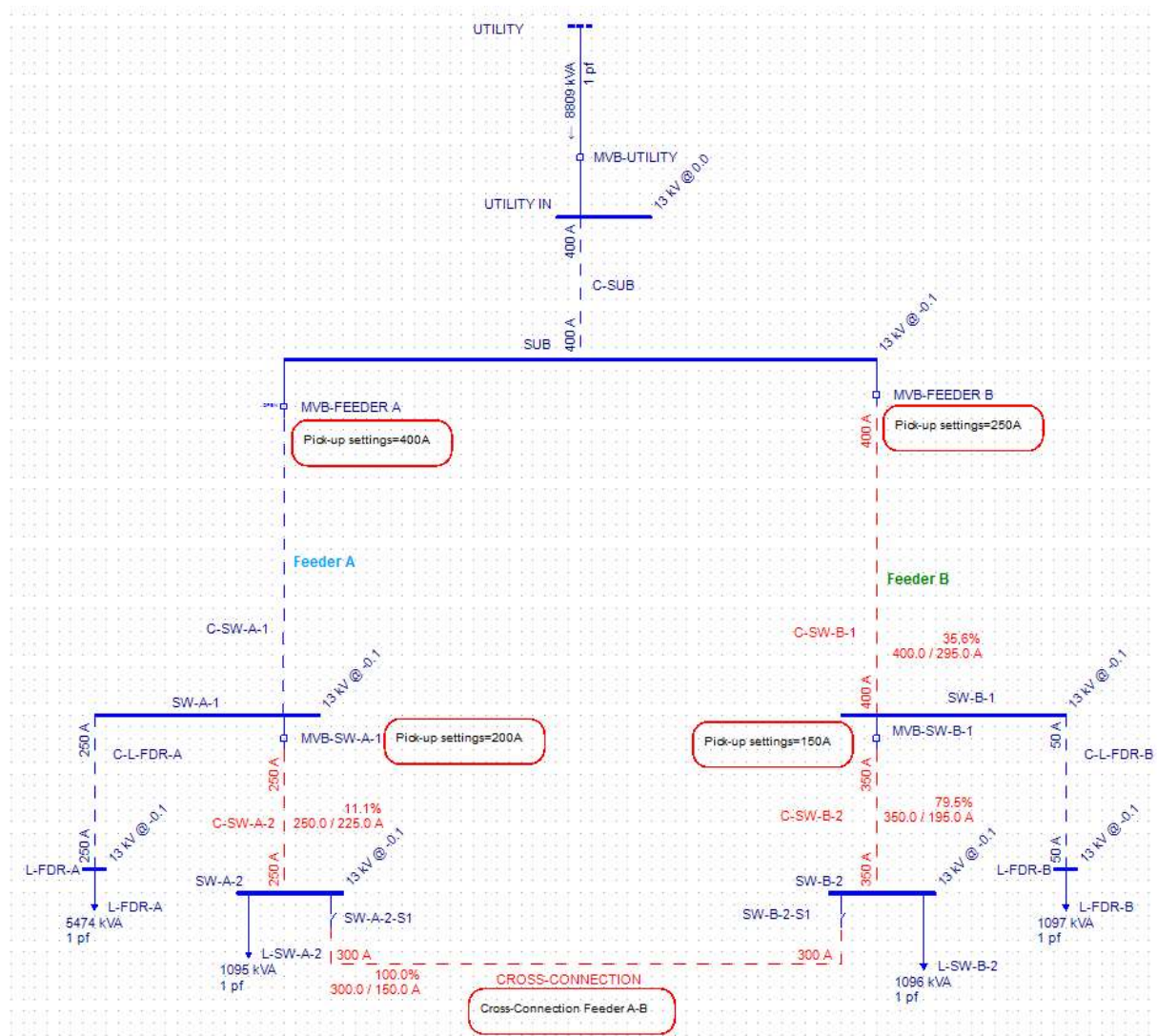


Figure 5-3
Feeder B serving A

In this cross-connect situation, it is observed that the additional load to Feeder B cannot be supported based on the following conditions.

- Feeder pick-up settings are lower than the combined load.
- The up-stream protective setting is lower than the cross-connect load.
- The down-stream protective setting is lower than the cross-connect load.
- Feeder cables are overloaded.
- Cross-Connect cable is overloaded.

Note: Anyone of the five conditions noted above will result in a non-viable cross-connect.

5.4 Concluding Remarks

The cross-connection study determines whether the existing distribution system has adequate cross-connection capability to allow any distribution feeder to be sub-fed from another feeder. The study considers and identifies any single point of failure where an unwanted electrical event or maintenance operations could not be isolated without resulting in widespread outages. In addition, to assess the capability of a feeder serving load to be sub-fed from an alternate feeder during peak loading. Identified deficiencies are evaluated for cross connect capability and a recommendation is provided.

The following analysis was performed with Substations Alpha, Bravo, and Charlie operating concurrently, without enabling any cross-connections. This approach ensures that only one cross-connection is evaluated at a time, providing more accurate values for each cross-connection.

The Cross Connect Study uses the following Basis of Assessment as interpreted from the PWS:

1. Feeders are studied to identify a single point of failure, in the normal operating configuration, that results in widespread outages. Namely, a point of failure that could cause an entire feeder outage.
2. Identification of available and viable cross-connects that adequately satisfy power flow requirements for the feeder contingency.
3. Where an adequate cross-connect does not exist, we provide recommendation(s) to establish a viable cross connect for the feeder contingency

Cross-connection capability at Dyess AFB is:

C.C. #1: Dyess AFB's 12.47 kV Pole "P-A2-1A" Ties FDR A1 and FDR A2 through Switch S+C#11.

C.C. #2: Dyess AFB's 12.47 kV Pole "P-B4-108A" Ties FDR A1 and FDR B4 through Switch S+C#14.

C.C. #3: Dyess AFB's 12.47 kV Pole "P-C1-10A" Ties FDR A2 and FDR C1 through Switch S+C#13.

C.C. #4: Dyess AFB's 12.47 kV Pole "P-B2-3" Ties FDR B1 and FDR B2 through Fused Switch P-B2-3.

C.C. #5: Dyess AFB's 12.47 kV Pole "P-B2-L1-7" Ties FDR B1 and FDR B2 through Switch P-B2-L1-7.

C.C. #6: Dyess AFB's 12.47 kV Pole "P-B1-32" Ties FDR B1 and FDR B2 through Fused Switch P-B1-32.

C.C. #7: Dyess AFB's 12.47 kV Pole "P-B2-L2-5" Ties FDR B1 and FDR B2 through Switch P-B2-L2-5.

- C.C. #8: Dyess AFB's 12.47 kV Pole "P-B1-42A" Ties FDR B1 and FDR C4 through Switch S+C#1.
- C.C. #9: Dyess AFB's 12.47 kV Pole "P-B3-L1-8" Ties FDR B2 and FDR B3 through Fused Switch P-B3-L1-8.
- C.C. #10: Dyess AFB's 12.47 kV Pole "P-B2-L3-4" Ties FDR B2 and FDR C2 through Switch P-B2-L3-4.
- C.C. #11: Dyess AFB's 12.47 kV Pole "P-C4-51" Ties FDR B2 and FDR C4 through Fused Switch P-C4-51.
- C.C. #12: Dyess AFB's 12.47 kV Pole "P-C4-L10-3" Ties FDR B2 and FDR C4 through Fused Switch P-C4-L10-3.
- C.C. #13: Dyess AFB's 12.47 kV Pole "P-B2-53" Ties FDR B2 and FDR C4 through Fused Switch P-B2-53.
- C.C. #14: Dyess AFB's 12.47 kV Pole "P-B2-64" Ties FDR B2 and FDR C3 through Switch S+C#3.
- C.C. #15: Dyess AFB's 12.47 kV Pole "P-B2-67" Ties FDR B2 and FDR C4 through Switch P-B2-67.
- C.C. #16: Dyess AFB's 12.47 kV Pole "P-B4-L1-8" Ties FDR B3 and FDR B4 through Fused Switch P-B4-L1-8.
- C.C. #17: Dyess AFB's 12.47 kV Pole "P-B3-26A" Ties FDR B3 and FDR C2 through Switch S+C#2.
- C.C. #18: Dyess AFB's 12.47 kV Pad Mount Switch "SB3-015" Ties FDR B3 and FDR C2 through Switch SB3-015-T2.
- C.C. #19: Dyess AFB's 12.47 kV Pole "P-C2-L1-24" Ties FDR B4 and FDR C2 through Switch C2-L1-24.
- C.C. #20: Dyess AFB's 12.47 kV Pole "P-C4-26" Ties FDR C3 and FDR C4 through Fused Switch P-C4-26.
- C.C. #21: Dyess AFB's 12.47 kV Pole "P-C4-30" Ties FDR C3 and FDR C4 through Fused Switch P-C4-30.
- C.C. #22: Dyess AFB's 12.47 kV Pole "P-C4-L4-7" Ties FDR C4 and FDR C5 through Switch S+C#6.
- C.C. #23: Dyess AFB's 12.47 kV Pole "P-C5-21" Ties FDR C4 and FDR C5 through Fused Switch P-C5-21.

Feeder A1:

Two Points of Cross-Connection were considered for Feeder A1. Below they have been summarized:

C.C. #1: Dyess AFB's 12.47 kV Pole "P-A2-1A" Ties FDR A1 and FDR A2 through Switch S+C#11.

C.C. #2: Dyess AFB's 12.47 kV Pole "P-B4-108A" Ties FDR A1 and FDR B4 through Switch S+C#14.

These Cross-Connections have been evaluated to determine the capability of Feeder A1 to carry the additional load of Feeder A2 or Feeder B4. The results are shown below:

Table 5-1
Cross-Connections served by Feeder A1

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection Operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 1	FDR A2	S+C#11	330	164.91	49.97%	45.81%	No
C.C # 2	FDR B4	S+C#14	330	91.10	27.61%	25.31%	No

The identified cross connections are considered viable options.

Feeder A2:

Two Points of Cross-Connection were considered for Feeder A2. Below they have been summarized:

C.C. #1: Dyess AFB's 12.47 kV Pole "P-A2-1A" Ties FDR A1 and FDR A2 through Switch S+C#11.

C.C. #3: Dyess AFB's 12.47 kV Pole "P-C1-10A" Ties FDR A2 and FDR C1 through Switch S+C#13.

These Cross-Connections have been evaluated to determine the capability of Feeder A2 to carry the additional load of Feeder A1 or Feeder C1. The result is shown below:

Table 5-2
Cross-Connections served by Feeder A2

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 1	FDR A1	S+C#11	330	164.91	49.97%	45.81%	No
C.C # 3	FDR C1	S+C#13	330	105.57	31.99%	29.33%	No

Note: C.C #3 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder B1:

Five Points of Cross-Connection were considered for Feeder B1. Below they have been summarized:

C.C. #4: Dyess AFB's 12.47 kV Pole "P-B2-3" Ties FDR B1 and FDR B2 through Fused Switch P-B2-3.

C.C. #5: Dyess AFB's 12.47 kV Pole "P-B2-L1-7" Ties FDR B1 and FDR B2 through Switch P-B2-L1-7.

C.C. #6: Dyess AFB's 12.47 kV Pole "P-B1-32" Ties FDR B1 and FDR B2 through Fused Switch P-B1-32.

C.C. #7: Dyess AFB's 12.47 kV Pole "P-B2-L2-5" Ties FDR B1 and FDR B2 through Switch P-B2-L2-5.

C.C. #8: Dyess AFB's 12.47 kV Pole "P-B1-42A" Ties FDR B1 and FDR C4 through Switch S+C#1.

These Cross-Connections have been evaluated to determine the capability of Feeder B1 to carry the additional load of Feeder B2 or Feeder C4. The result is shown below:

Table 5-3
Cross-Connections served by Feeder B1

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 4	FDR B2	P-B2-3	330	85.40	25.88%	49.31%	No
C.C # 5	FDR B2	P-B2-L1-7	330	85.41	25.88%	49.31%	No
C.C # 6	FDR B2	P-B1-32	330	85.42	25.88%	49.32%	No
C.C # 7	FDR B2	P-B2-L2-5	330	85.38	25.87%	49.29%	No
C.C # 8	FDR C4	S+C#1	330	82.89	25.12%	47.86%	No

Note: C.C #8 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder B2:

Eleven Points of Cross-Connection were considered for Feeder B2. Below they have been summarized:

C.C. #4: Dyess AFB's 12.47 kV Pole "P-B2-3" Ties FDR B1 and FDR B2 through Fused Switch P-B2-3.

C.C. #5: Dyess AFB's 12.47 kV Pole "P-B2-L1-7" Ties FDR B1 and FDR B2 through Switch P-B2-L1-7.

C.C. #6: Dyess AFB's 12.47 kV Pole "P-B1-32" Ties FDR B1 and FDR B2 through Fused Switch P-B1-32.

C.C. #7: Dyess AFB's 12.47 kV Pole "P-B2-L2-5" Ties FDR B1 and FDR B2 through Switch P-B2-L2-5.

C.C. #9: Dyess AFB's 12.47 kV Pole "P-B3-L1-8" Ties FDR B2 and FDR B3 through Fused Switch P-B3-L1-8.

C.C. #10: Dyess AFB's 12.47 kV Pole "P-B2-L3-4" Ties FDR B2 and FDR C2 through Switch P-B2-L3-4.

C.C. #11: Dyess AFB's 12.47 kV Pole "P-C4-51" Ties FDR B2 and FDR C4 through Fused Switch P-C4-51.

C.C. #12: Dyess AFB's 12.47 kV Pole "P-C4-L10-3" Ties FDR B2 and FDR C4 through Fused Switch P-C4-L10-3.

C.C. #13: Dyess AFB's 12.47 kV Pole "P-B2-53" Ties FDR B2 and FDR C4 through Fused Switch P-B2-53.

C.C. #14: Dyess AFB's 12.47 kV Pole "P-B2-64" Ties FDR B2 and FDR C3 through Switch S+C#3.

C.C. #15: Dyess AFB's 12.47 kV Pole "P-B2-67" Ties FDR B2 and FDR C4 through Switch P-B2-67.

These Cross-Connections have been evaluated to determine the capability of Feeder B2 to carry the additional load of Feeder B1, B3, C2, C3 or C4. The result is shown below:

Table 5-4
Cross-Connections served by Feeder B2

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 4	FDR B1	P-B2-3	330	85.39	25.88%	49.30%	No
C.C # 5	FDR B1	P-B2-L1-7	330	85.40	25.88%	49.31%	No
C.C # 6	FDR B1	P-B1-32	330	85.40	25.88%	49.31%	No
C.C # 7	FDR B1	P-B2-L2-5	330	85.43	25.89%	49.32%	No
C.C # 9	FDR B3	P-B3-L1-8	330	92.37	27.99%	53.33%	No
C.C # 10	FDR C2	P-B2-L3-4	330	148.80	45.09%	85.91%	No
C.C # 11	FDR C4	P-C4-51	330	139.46	42.26%	80.52%	No
C.C # 12	FDR C4	P-C4-L10-3	330	139.48	42.27%	80.53%	No
C.C # 13	FDR C4	P-B2-53	330	139.48	42.27%	80.53%	No
C.C # 14	FDR C3	S+C#3	330	124.26	37.65%	71.74%	No
C.C # 15	FDR C4	P-B2-67	330	139.50	42.27%	80.54%	No

Note: C.C #14 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder B3:

Four Points of Cross-Connection were considered for Feeder B3. Below they have been summarized:

C.C. #9: Dyess AFB's 12.47 kV Pole "P-B3-L1-8" Ties FDR B2 and FDR B3 through Fused Switch P-B3-L1-8.

C.C. #16: Dyess AFB's 12.47 kV Pole "P-B4-L1-8" Ties FDR B3 and FDR B4 through Fused Switch P-B4-L1-8.

C.C. #17: Dyess AFB's 12.47 kV Pole "P-B3-26A" Ties FDR B3 and FDR C2 through Switch S+C#2.

C.C. #18: Dyess AFB's 12.47 kV Pad Mount Switch "SB3-015" Ties FDR B3 and FDR C2 through Switch SB3-015-T2.

These Cross-Connections have been evaluated to determine the capability of Feeder B3 to carry the additional load of Feeder B2, B4, or C2. The result is shown below:

Table 5-5
Cross-Connections served by Feeder B3

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 9	FDR B2	P-B3-L1-8	330	92.45	28.02%	53.38%	No
C.C # 16	FDR B4	P-B4-L1-8	330	53.42	16.19%	30.84%	No
C.C # 17	FDR C2	S+C#2	330	100.14	30.35%	57.82%	No
C.C # 18	FDR C2	SB3-015-T2	330	100.22	30.37%	57.86%	No

Note: C.C #17 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder B4:

Three Points of Cross-Connection were considered for Feeder B4. Below they have been summarized:

C.C. #2: Dyess AFB's 12.47 kV Pole "P-B4-108A" Ties FDR A1 and FDR B4 through Switch S+C#14.

C.C. #16: Dyess AFB's 12.47 kV Pole "P-B4-L1-8" Ties FDR B3 and FDR B4 through Fused Switch P-B4-L1-8.

C.C. #19: Dyess AFB's 12.47 kV Pole "P-C2-L1-24" Ties FDR B4 and FDR C2 through Switch C2-L1-24.

These Cross-Connections have been evaluated to determine the capability of Feeder B4 to carry the additional load of Feeder A1, B3, or C2. The result is shown below:

Table 5-6
Cross-Connections served by Feeder B4

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 2	FDR A1	S+C#14	330	90.30	27.36%	52.13%	No
C.C # 16	FDR B3	P-B4-L1-8	330	53.37	16.17%	30.81%	No
C.C # 19	FDR C2	C2-L1-24 SB4-020-3	330	109.80	33.27%	63.39%	No

The identified cross connections are considered viable options.

Feeder C1:

One Point of Cross-Connection was considered for Feeder C1. Below it has been summarized:

C.C. #3: Dyess AFB's 12.47 kV Pole "P-C1-10A" Ties FDR A2 and FDR C1 through Switch S+C#13.

This Cross-Connection has been evaluated to determine the capability of Feeder C1 to carry the additional load of Feeder A2. The result is shown below:

Table 5-7
Cross-Connections served by Feeder C1

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 3	FDR A2	S+C#13	330	105.54	31.98%	35.18%	No

Note: C.C #3 is currently integrated within the model's normal configuration.

The identified cross connection is considered a viable option.

Feeder C2:

Four Points of Cross-Connection were considered for Feeder C2. Below they have been summarized:

C.C. #10: Dyess AFB's 12.47 kV Pole "P-B2-L3-4" Ties FDR B2 and FDR C2 through Switch P-B2-L3-4.

C.C. #17: Dyess AFB's 12.47 kV Pole "P-B3-26A" Ties FDR B3 and FDR C2 through Switch S+C#2.

C.C. #18: Dyess AFB's 12.47 kV Pad Mount Switch "SB3-015" Ties FDR B3 and FDR C2 through Switch SB3-015-T2.

C.C. #19: Dyess AFB's 12.47 kV Pole "P-C2-L1-24" Ties FDR B4 and FDR C2 through Switch C2-L1-24.

These Cross-Connections have been evaluated to determine the capability of Feeder C2 to carry the additional load of Feeder B2, B3, or B4. The result is shown below:

Table 5-8
Cross-Connections served by Feeder C2

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 10	FDR B2	P-B2-L3-4	330	150.55	45.62%	50.18%	No
C.C # 17	FDR B3	S+C#2	330	101.26	30.68%	33.75%	No
C.C # 18	FDR B3	SB3-015-T2	330	101.26	30.68%	33.75%	No
C.C # 19	FDR B4	C2-L1-24 SB4-020-3	330	110.48	33.48%	36.83%	No

Note: C.C #17 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder C3:

Three Points of Cross-Connection were considered for Feeder C3. Below they have been summarized:

C.C. #14: Dyess AFB's 12.47 kV Pole "P-B2-64" Ties FDR B2 and FDR C3 through Switch S+C#3.

C.C. #20: Dyess AFB's 12.47 kV Pole "P-C4-26" Ties FDR C3 and FDR C4 through Fused Switch P-C4-26.

C.C. #21: Dyess AFB's 12.47 kV Pole "P-C4-30" Ties FDR C3 and FDR C4 through Fused Switch P-C4-30.

These Cross-Connections have been evaluated to determine the capability of Feeder C3 to carry the additional load of Feeder B2, or C4. The result is shown below:

Table 5-9
Cross-Connections served by Feeder C3

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 14	FDR B2	S+C#3	330	127.28	38.57%	42.43%	No
C.C # 20	FDR C4	P-C4-26	330	126.32	38.28%	42.11%	No
C.C # 21	FDR C4	P-C4-30	330	126.41	38.31%	42.14%	No

Note: C.C #14 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder C4:

Nine Points of Cross-Connection were considered for Feeder C4. Below they have been summarized:

C.C. #8: Dyess AFB's 12.47 kV Pole "P-B1-42A" Ties FDR B1 and FDR C4 through Switch S+C#1.

C.C. #11: Dyess AFB's 12.47 kV Pole "P-C4-51" Ties FDR B2 and FDR C4 through Fused Switch P-C4-51.

C.C. #12: Dyess AFB's 12.47 kV Pole "P-C4-L10-3" Ties FDR B2 and FDR C4 through Fused Switch P-C4-L10-3.

C.C. #13: Dyess AFB's 12.47 kV Pole "P-B2-53" Ties FDR B2 and FDR C4 through Fused Switch P-B2-53.

C.C. #15: Dyess AFB's 12.47 kV Pole "P-B2-67" Ties FDR B2 and FDR C4 through Switch P-B2-67.

C.C. #20: Dyess AFB's 12.47 kV Pole "P-C4-26" Ties FDR C3 and FDR C4 through Fused Switch P-C4-26.

C.C. #21: Dyess AFB's 12.47 kV Pole "P-C4-30" Ties FDR C3 and FDR C4 through Fused Switch P-C4-30.

C.C. #22: Dyess AFB's 12.47 kV Pole "P-C4-L4-7" Ties FDR C4 and FDR C5 through Switch S+C#6.

C.C. #23: Dyess AFB's 12.47 kV Pole "P-C5-21" Ties FDR C4 and FDR C5 through Fused Switch P-C5-21.

These Cross-Connections have been evaluated to determine the capability of Feeder C4 to carry the additional load of Feeder B1, B2, C3, or C5. The result is shown below:

Table 5-10
Cross-Connections served by Feeder C4

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 8	FDR B1	S+C#1	330	83.13	25.19%	27.71%	No
C.C # 11	FDR B2	P-C4-51	330	140.59	42.60%	46.86%	No
C.C # 12	FDR B2	P-C4-L10-3	330	140.52	42.58%	46.84%	No
C.C # 13	FDR B2	P-B2-53	330	140.53	42.58%	46.84%	No
C.C # 15	FDR B2	P-B2-67	330	140.38	42.54%	46.79%	No
C.C # 20	FDR C3	P-C4-26	330	126.43	38.31%	42.14%	No
C.C # 21	FDR C3	P-C4-30	330	126.44	38.32%	42.15%	No
C.C # 22	FDR C5	S+C#6	330	129.98	39.39%	43.33%	No
C.C # 23	FDR C5	P-C5-21	330	130.07	39.42%	43.36%	No

Note: C.C #8 and C.C #22 are currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Feeder C5:

Two Points of Cross-Connection were considered for Feeder C5. Below they have been summarized:

C.C. #22: Dyess AFB's 12.47 kV Pole "P-C4-L4-7" Ties FDR C4 and FDR C5 through Switch S+C#6.

C.C. #23: Dyess AFB's 12.47 kV Pole "P-C5-21" Ties FDR C4 and FDR C5 through Fused Switch P-C5-21.

These Cross-Connections have been evaluated to determine the capability of Feeder C5 to carry the additional load of Feeder C4. The result is shown below:

Table 5-11
Cross-Connections served by Feeder C5

Cross-Connection	Cross-Connection Operating position (OPEN)	Cross-Connection operating position (CLOSE)	Feeder Ampacity	Main Feeder Loading	Percent Cross-Connect cable loading	Maximum percent circuit loading (Relative to protective pickup)	Significant Voltage drop (>5%)
C.C # 22	FDR C4	S+C#6	330	129.99	39.39%	43.33%	No
C.C # 23	FDR C4	P-C5-21	330	130.07	39.42%	43.36%	No

Note: C.C #22 is currently integrated within the model's normal configuration.

The identified cross connections are considered viable options.

Dyess AFB has valid cross-connections present on all Feeders. Furthermore, all twenty-three (23) points of cross-connection above have been found to be valid.

6

SHORT CIRCUIT ANALYSIS

Section 6 provides the short circuit analysis for the electrical system. Refer to Appendix K for the short circuit tables.

6.1 Purpose of Short Circuit Analysis

A short circuit study is an integral and necessary part of selecting and sizing electrical distribution components. Even the best and most reliable electrical distribution system is not immune to occasional short circuits. The objectives of the short circuit analysis include:

- Determine short circuit current levels throughout the system.
- Confirm that system protective device interrupting ratings are not exceeded.
- Establish fault current levels for use in the coordination study.
- Identify system lineups or configurations that realize unacceptably high levels of fault current.

Section 1 provides additional background information regarding short circuit studies. This section provides a summary of the EasyPower short circuit analysis. Short circuit levels are provided for key locations throughout the primary distribution system. Equipment duty evaluation results are provided for major equipment and any components that are over duty, i.e., operating beyond its short circuit rating. The Short Circuit folder contains short circuit summary reports for the entire system, including:

- Three phase fault levels for all primary / low voltage buses.
- Single-phase-to-ground fault levels for all primary / low voltage buses.

Comprehensive graphical and text reports containing short circuit and equipment duty information for all system elements are readily available from the EasyPower model. Additional fault types can also be viewed in EasyPower.

6.2 Interpreting Short Circuit Analysis Results

Short circuit analysis results can be viewed directly on the EasyPower one-line diagram. A typical EasyPower short circuit display is shown in Figure 6-1. The user controls the type of fault applied to the system and which elements of fault currents are to be displayed. Options include: ½ cycle, 5 cycle, and 30 cycle fault current; symmetrical, asymmetrical, or equipment duty fault current elements; and three-phase, single line-to-ground, line-to-line, or double line-to-ground faults.

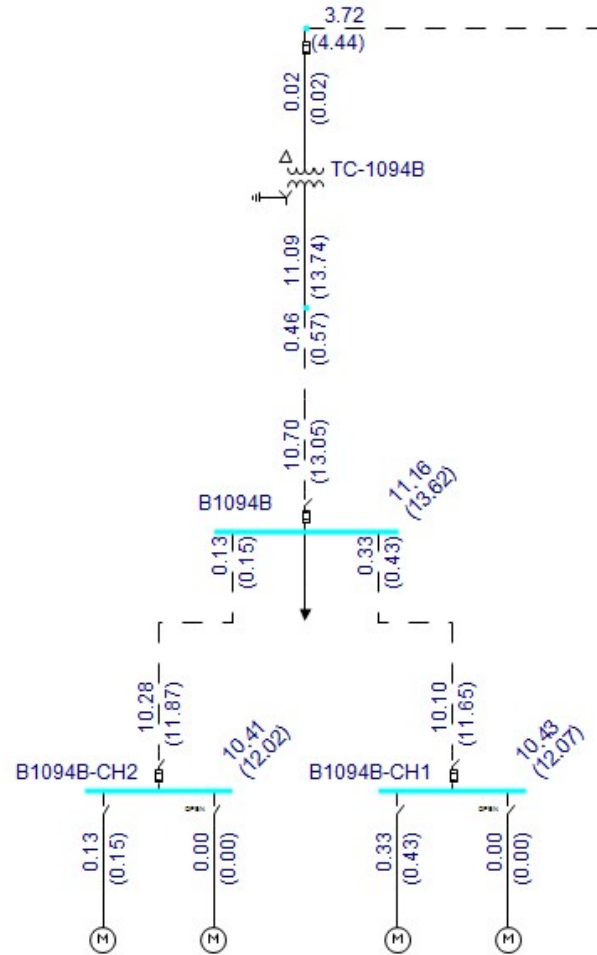


Figure 6-1
Typical EasyPower Short Circuit Result

Referring to Figure 6-1, the interpretation of a typical EasyPower short circuit display is as follows:

- The maximum available feeder short circuit current into Transformer TC-1094B is 3,720 symmetrical amperes and 4,440 asymmetrical amperes.
- The maximum available short circuit current out of Transformer TC-1094B is 11,090 symmetrical amperes and 13,740 asymmetrical amperes.
- The short circuit current at the service entrance panel for Transformer TC-1094B is 11,160 symmetrical amperes and 13,620 asymmetrical amperes.
- Two motors also contribute to the short circuit current. One motor contributes 130 symmetrical amperes and 150 asymmetrical amperes on the low voltage side of the transformer. The other motor contributes 330 symmetrical amperes and 430 asymmetrical amperes on the low voltage

side of the transformer. For a fault on the primary distribution system, the motors contribute 20 symmetrical amperes and 20 asymmetrical amperes at the 12.47 kV level.

Different types of faults produce different levels of short circuit current. The most common type of fault considered is a three-phase bolted fault. A three-phase bolted fault generally bounds other types of faults in terms of maximum fault current. Line to ground fault current levels are also important to determine. In some cases, ground fault current can be higher than the three-phase bolted fault current. Additionally, ground fault current levels are important for evaluating coordination of ground fault protective devices.

The fault current magnitude changes over the first several cycles after a short circuit occurs in an AC power system. The change is due to 1) the decaying contribution of motors and generators, and 2) a phenomenon known as *DC offset*. DC offset causes the symmetrical current waveform to shift above the zero-axis, producing an asymmetrical waveform – refer to Figure 6-2 and Figure 6-3. This effect decays away exponentially; however, it has the effect of increasing the peak fault current seen by system equipment. All these factors are considered in determining equipment short circuit ratings. The practical consequence of decaying fault current levels is that the highest current to which the equipment is exposed occurs within about the first $\frac{1}{2}$ cycle. This fault current quantity is called the *momentary fault current*.

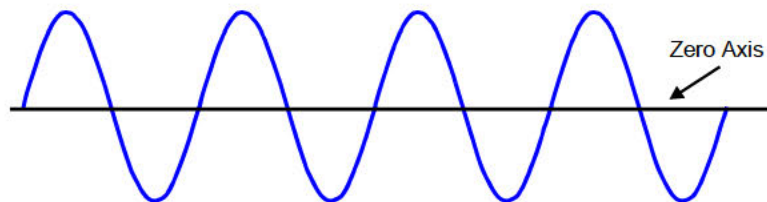


Figure 6-2
Symmetrical Current Waveform

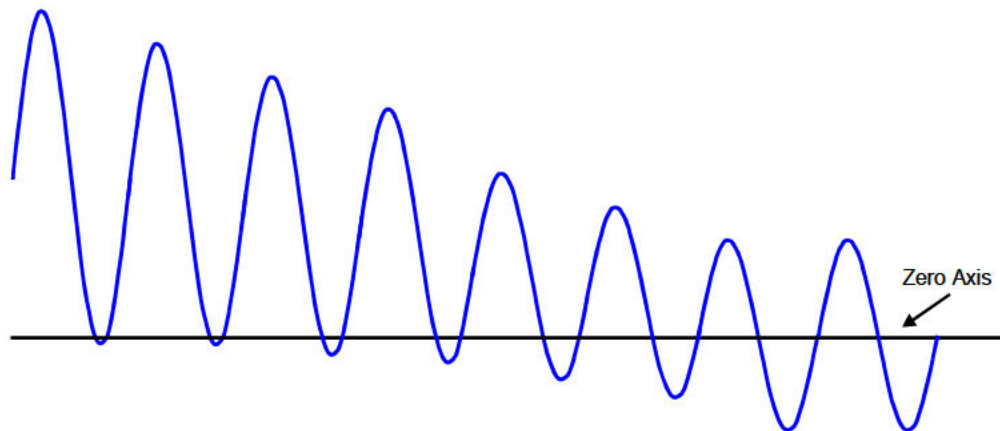


Figure 6-3
Asymmetrical Current Waveform

The most commonly used fault current quantities are momentary symmetrical and asymmetrical fault current for three-phase and ground faults. Because of the importance of asymmetrical fault

current values to the overall analysis, it is generally advisable to set the EasyPower display parameters to show both symmetrical and asymmetrical fault current at each bus.

6.3 Short Circuit Analysis Results

Resulting from the Short Circuit Analysis, the equipment violations and warnings have been detailed in the following table. For a comprehensive list of all equipment, please refer to the Short Circuit Equipment Duty Reports located in Appendix K of Volume 2.

Table 6-1
Base Case – Utility – As-Found Short Circuit Warnings & Violations

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
B95S1-1 IN	GE	SCP	14.42	44.2%	VIOLATION	14.42	44.2%	VIOLATION
B95S1-2 IN	GE	SCP	16.85	68.5%	VIOLATION	16.85	68.5%	VIOLATION
B95S1-3 IN	GE	SCP	14.26	42.6%	VIOLATION	14.26	42.6%	VIOLATION
B95S2-2 IN	GE	SCP	15.46	54.6%	VIOLATION	15.46	54.6%	VIOLATION
B95S2-3 IN	GE	SCP	14.21	42.1%	VIOLATION	14.21	42.1%	VIOLATION
B95S2-4 IN	GE	SCP	14.14	41.4%	VIOLATION	14.14	41.4%	VIOLATION
B95S2-5 IN	GE	SCP	14.08	40.8%	VIOLATION	14.08	40.8%	VIOLATION
B95S2-6 IN	GE	SCP	11.37	13.7%	VIOLATION	11.37	13.7%	VIOLATION
LVB-B4201 (MAIN)	GE	TQD	13.36	33.6%	VIOLATION	13.36	33.6%	VIOLATION
B4201 (B) OUT	GE	Q	13.36	33.6%	VIOLATION	13.36	33.6%	VIOLATION
B4218 SE2 (MLO)	SQD		11.64	16.4%	VIOLATION	N/A	N/A	N/A
B5015 (MDP MLO)	GE	QMR	12.32	23.2%	VIOLATION	9.19	-8.1%	Warning
B5130 OUT	SQD		11.06	10.6%	VIOLATION	N/A	N/A	N/A
B5280 OUT	SQD		11.13	11.3%	VIOLATION	N/A	N/A	N/A
B6137 SE2	BUSS	NON(H) 100-600A	12.02	20.2%	VIOLATION	N/A	N/A	N/A
LVB-B7106B SE2	Siemens	QP 2P	18.08	80.8%	VIOLATION	18.08	80.8%	VIOLATION
B7106B SE2 IN	GE		18.08	80.8%	VIOLATION	18.08	80.8%	VIOLATION

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
B7206 (PANEL M) SE1 OUT	SQD	HCN	15.28	9.1%	VIOLATION	N/A	N/A	N/A
B7206 SE2	Siemens	QP 2P	14.72	47.2%	VIOLATION	14.72	47.2%	VIOLATION
B7206 IN	GE	TLM	14.48	44.8%	VIOLATION	14.48	44.8%	VIOLATION
FDSC-B7216	BUSS	NON(H) 100-600A	13.71	37.1%	VIOLATION	10.46	4.6%	VIOLATION
B7216 IN	SQD	Safety Switch	12.59	25.9%	VIOLATION	9.98	-0.2%	Warning
LVB-B7416	SQD	QB	12.83	28.3%	VIOLATION	12.83	28.3%	VIOLATION
B7416 (PANEL A) IN	SQD		12.83	28.3%	VIOLATION	12.83	28.3%	VIOLATION
B8006 SE2 OUT	SQD		13.43	34.3%	VIOLATION	N/A	N/A	N/A
LVB-B8011 SE1	SQD	QB	17.67	76.7%	VIOLATION	N/A	N/A	N/A
B8011 SE1 IN			17.67	76.7%	VIOLATION	N/A	N/A	N/A
LVB-B8080A	GE	THQL	11.20	12.0%	VIOLATION	N/A	N/A	N/A
B8080A IN	GE		11.20	12.0%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE1 (MAIN)	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE1 (PNL A) IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE2 (MAIN)	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE2 (PNL B) IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
LVB-B11955A SE3	SQD	QBL	14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE3 IN	SQD		14.17	41.7%	VIOLATION	N/A	N/A	N/A
B11955A SE4 (MLO)	Buss		15.08	50.8%	VIOLATION	9.20	-8.0%	Warning
B11955B (MLO)	SQD		9.18	-8.2%	Warning	N/A	N/A	N/A
BP4218 SE1 OUT			9.10	-9.0%	Warning	N/A	N/A	N/A
B-BOMBPAD OUT			9.33	-6.7%	Warning	N/A	N/A	N/A

EQUIPMENT ID	Manufacturer	Style	3 Phase Fault			Line – Ground Fault		
			½ Cycle KA	½ Cycle Percent	Status	½ Cycle KA	½ Cycle Percent	Status
LVB-B-RAMP4	SQD	QOM 2	9.91	-0.9%	Warning	9.91	-0.9%	Warning
B-RAMP4 IN	SQD	QOM	9.91	-0.9%	Warning	9.91	-0.9%	Warning
LVB-B4202 (MISSION ESSEN.)	GE	TQD	9.83	-1.7%	Warning	N/A	N/A	N/A
B5020 IN	EATON		13.43	-4.0%	Warning	14.52	3.7%	VIOLATION
LVB-B7233 SE1B	Cutler Hammer	BAB	9.17	-8.3%	Warning	N/A	N/A	N/A
B7233 (7-05) SE1B IN	Westinghouse	PRL1	9.17	-8.3%	Warning	N/A	N/A	N/A

Note: Short circuit violations are any device where the available fault current is higher than the Short Circuit rating of the device (i.e., overduty). A warning would be any device that is within 10% of being overdutied. Recommendations for replacements are included in the budget at the end of Section 11.

Note: Columns with “N/A” mean that this location did not have any Warnings and Violations for that respective fault, either 3-Phase or Line-Ground. For example, B7233 (7-05) SE1B IN has a warning for a 3-Phase fault but no Warning or Violations for a Line-Ground fault.

Table 6-2
Base Case – Utility - Short Circuit Violations and Warnings for XFMR Fuses

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T-25A-FUSE	7.2	BAY-O-NET	4.022	14.90%	VIOLATION	4.022	14.9%	VIOLATION
T-40A-FUSE	7.2	BAY-O-NET	4.171	19.20%	VIOLATION	4.171	19.2%	VIOLATION
T-43A-FUSE	7.2	BAY-O-NET	3.533	0.90%	VIOLATION	3.533	0.9%	VIOLATION
T-86-FUSE	7.2	BAY-O-NET	3.724	6.40%	VIOLATION	3.724	6.4%	VIOLATION
T-87-FUSE	7.2	BAY-O-NET	4.022	14.90%	VIOLATION	4.022	14.9%	VIOLATION
T-BESS-FUSE	12.47	BAY-O-NET	6.192	76.90%	VIOLATION	5.606	60.2%	VIOLATION
T-BOMBPAD-FUSE	12.47	BAY-O-NET	3.72	48.80%	VIOLATION	2.551	2.0%	VIOLATION
T-EG1 PRI	12.47	BAY-O-NET	6.189	76.80%	VIOLATION	5.596	59.9%	VIOLATION
T-LT1 IN	7.2	BAY-O-NET	2.999	20.00%	VIOLATION	2.999	20.0%	VIOLATION
T-LT1-FUSE	7.2	BAY-O-NET	2.999	20.00%	VIOLATION	2.999	20.0%	VIOLATION
T-LT22-FUSE	12.47	BAY-O-NET	3.071	22.80%	VIOLATION	N/A	N/A	N/A
T-LT23-FUSE	12.47	BAY-O-NET	2.953	18.10%	VIOLATION	N/A	N/A	N/A

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T-LT24-FUSE	12.47	BAY-O-NET	2.798	11.90%	VIOLATION	N/A	N/A	N/A
T-NAOC-F	12.47	BAY-O-NET	3.49	39.60%	VIOLATION	2.307	-7.7%	Warning
T1-1A-FUSE	7.2	BAY-O-NET	3.612	3.20%	VIOLATION	3.612	3.2%	VIOLATION
T1-6-FUSE	7.2	BAY-O-NET	3.506	0.20%	VIOLATION	3.506	0.2%	VIOLATION
T1-7-FUSE	7.2	BAY-O-NET	3.622	3.50%	VIOLATION	3.622	3.5%	VIOLATION
T1-8-FUSE	7.2	BAY-O-NET	3.668	4.80%	VIOLATION	3.668	4.8%	VIOLATION
T1-9-FUSE	7.2	BAY-O-NET	3.717	6.20%	VIOLATION	3.717	6.2%	VIOLATION
T1-10-FUSE	7.2	BAY-O-NET	3.827	9.30%	VIOLATION	3.827	9.3%	VIOLATION
T1-11-FUSE	7.2	BAY-O-NET	3.781	8.00%	VIOLATION	3.781	8.0%	VIOLATION
T1-12-FUSE	7.2	BAY-O-NET	3.728	6.50%	VIOLATION	3.728	6.5%	VIOLATION
T1-13-FUSE	7.2	BAY-O-NET	3.629	3.70%	VIOLATION	3.629	3.7%	VIOLATION
T1-17 IN	7.2	BAY-O-NET	3.83	9.40%	VIOLATION	3.83	9.4%	VIOLATION
T1-18-FUSE	7.2	BAY-O-NET	3.903	11.50%	VIOLATION	3.903	11.5%	VIOLATION
T1-19-FUSE	7.2	BAY-O-NET	4.027	15.10%	VIOLATION	4.027	15.1%	VIOLATION
T1-20-FUSE	7.2	BAY-O-NET	4.216	20.50%	VIOLATION	4.216	20.5%	VIOLATION
T1-21-FUSE	7.2	BAY-O-NET	4.152	18.60%	VIOLATION	4.152	18.6%	VIOLATION
T1-22-FUSE	7.2	BAY-O-NET	3.991	14.00%	VIOLATION	3.991	14.0%	VIOLATION
T1-23-FUSE	7.2	BAY-O-NET	3.911	11.70%	VIOLATION	3.911	11.7%	VIOLATION
T1-24-FUSE	7.2	BAY-O-NET	3.817	9.10%	VIOLATION	3.817	9.1%	VIOLATION
T1-25-FUSE	7.2	BAY-O-NET	4.049	15.70%	VIOLATION	4.049	15.7%	VIOLATION
T1-26-FUSE	7.2	BAY-O-NET	3.802	8.60%	VIOLATION	3.802	8.6%	VIOLATION
T1-27-FUSE	7.2	BAY-O-NET	3.858	10.20%	VIOLATION	3.858	10.2%	VIOLATION
T1-28-FUSE	7.2	BAY-O-NET	3.963	13.20%	VIOLATION	3.963	13.2%	VIOLATION
T1-29-FUSE	7.2	BAY-O-NET	4.592	31.20%	VIOLATION	4.592	31.2%	VIOLATION
T1-30-FUSE	7.2	BAY-O-NET	4.561	30.30%	VIOLATION	4.561	30.3%	VIOLATION
T1-31-FUSE	7.2	BAY-O-NET	4.411	26.00%	VIOLATION	4.411	26.0%	VIOLATION
T1-44-FUSE	7.2	BAY-O-NET	3.563	1.80%	VIOLATION	3.563	1.8%	VIOLATION
T1-45-FUSE	7.2	BAY-O-NET	3.663	4.70%	VIOLATION	3.663	4.7%	VIOLATION
T1-46-FUSE	7.2	BAY-O-NET	3.746	7.00%	VIOLATION	3.746	7.0%	VIOLATION
T1-47-FUSE	7.2	BAY-O-NET	3.863	10.40%	VIOLATION	3.863	10.4%	VIOLATION
T1-48-FUSE	7.2	BAY-O-NET	3.917	11.90%	VIOLATION	3.917	11.9%	VIOLATION
T1-49-FUSE	7.2	BAY-O-NET	3.727	6.50%	VIOLATION	3.727	6.5%	VIOLATION
T5-1-FUSE	7.2	BAY-O-NET	3.547	1.30%	VIOLATION	3.547	1.3%	VIOLATION
T5-2-FUSE	7.2	BAY-O-NET	3.602	2.90%	VIOLATION	3.602	2.9%	VIOLATION
T3202 IN	12.47	BAY-O-NET	2.715	8.60%	VIOLATION	N/A	N/A	N/A
T4101-FUSE	12.47	BAY-O-NET	4.141	18.30%	VIOLATION	N/A	N/A	N/A

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T4170A-FUSE	12.47	BAY-O-NET	4.232	20.90%	VIOLATION	N/A	N/A	N/A
T4218 IN	12.47	BAY-O-NET	3.506	40.20%	VIOLATION	2.367	-5.3%	Warning
T4230-FUSE	12.47	BAY-O-NET	3.853	10.10%	VIOLATION	N/A	N/A	N/A
T4309A IN	12.47	BAY-O-NET	3.439	37.50%	VIOLATION	N/A	N/A	N/A
T4311-FUSE	12.47	BAY-O-NET	3.326	33.00%	VIOLATION	N/A	N/A	N/A
T4315 IN	12.47	BAY-O-NET	3.127	25.10%	VIOLATION	N/A	N/A	N/A
T4316A IN	12.47	BAY-O-NET	3.227	29.10%	VIOLATION	N/A	N/A	N/A
T4317A IN	12.47	BAY-O-NET	3.285	31.40%	VIOLATION	N/A	N/A	N/A
T4323 IN	12.47	BAY-O-NET	3.291	31.70%	VIOLATION	N/A	N/A	N/A
T5001 IN	12.47	BAY-O-NET	3.259	30.30%	VIOLATION	N/A	N/A	N/A
T5001B-FUSE	12.47	BAY-O-NET	3.258	30.30%	VIOLATION	N/A	N/A	N/A
T5005B IN	12.47	BAY-O-NET	3.213	28.50%	VIOLATION	N/A	N/A	N/A
T5013-FUSE	12.47	BAY-O-NET	2.79	11.60%	VIOLATION	N/A	N/A	N/A
T5130-FUSE	12.47	BAY-O-NET	2.833	13.30%	VIOLATION	N/A	N/A	N/A
T5160B-FUSE	12.47	BAY-O-NET	2.727	9.10%	VIOLATION	N/A	N/A	N/A
T5204B IN	12.47	BAY-O-NET	2.574	3.00%	VIOLATION	N/A	N/A	N/A
T5270-FUSE	12.47	BAY-O-NET	2.535	1.40%	VIOLATION	N/A	N/A	N/A
T5280-FUSE	12.47	BAY-O-NET	2.813	12.50%	VIOLATION	N/A	N/A	N/A
T6113-FUSE	12.47	BAY-O-NET	4.061	16.00%	VIOLATION	N/A	N/A	N/A
T6130-FUSE	12.47	BAY-O-NET	4.42	26.30%	VIOLATION	N/A	N/A	N/A
T6136A-FUSE	12.47	BAY-O-NET	4.327	73.10%	VIOLATION	2.551	2.0%	VIOLATION
T6136B-FUSE	12.47	BAY-O-NET	4.323	72.90%	VIOLATION	2.544	1.7%	VIOLATION
T6138B IN	12.47	BAY-O-NET	4.663	86.50%	VIOLATION	3.14	25.6%	VIOLATION
T6220-FUSE	12.47	BAY-O-NET	3.763	50.50%	VIOLATION	2.478	-0.9%	Warning
T6222-FUSE	12.47	BAY-O-NET	3.906	11.60%	VIOLATION	N/A	N/A	N/A
T7000A IN	12.47	BAY-O-NET	4.212	68.50%	VIOLATION	2.948	17.9%	VIOLATION
T7000B IN	12.47	BAY-O-NET	4.23	69.20%	VIOLATION	2.952	18.1%	VIOLATION
T7004A-FUSE	12.47	BAY-O-NET	4.315	23.30%	VIOLATION	N/A	N/A	N/A
T7004B-FUSE	12.47	BAY-O-NET	4.272	22.00%	VIOLATION	N/A	N/A	N/A
T7004D-FUSE	12.47	BAY-O-NET	4.127	65.10%	VIOLATION	2.778	11.1%	VIOLATION
T7007A-FUSE	12.47	BAY-O-NET	3.911	56.50%	VIOLATION	2.578	3.1%	VIOLATION
T7007B-FUSE	12.47	BAY-O-NET	3.904	56.10%	VIOLATION	2.566	2.6%	VIOLATION
T7008A-FUSE	12.47	BAY-O-NET	3.798	51.90%	VIOLATION	2.494	-0.2%	Warning
T7008B-F	12.47	BAY-O-NET	3.791	51.60%	VIOLATION	2.484	-0.6%	Warning
T7008C-F	12.47	BAY-O-NET	3.64	45.60%	VIOLATION	2.322	-7.1%	Warning
T7008D-F	12.47	BAY-O-NET	3.466	38.60%	VIOLATION	N/A	N/A	N/A

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T7101-FUSE	12.47	BAY-O-NET	4.345	73.80%	VIOLATION	3.047	21.9%	VIOLATION
T7104 IN	12.47	BAY-O-NET	4.272	70.90%	VIOLATION	2.937	17.5%	VIOLATION
T7106A-FUSE	12.47	BAY-O-NET	3.599	2.80%	VIOLATION	N/A	N/A	N/A
T7106B-FUSE	12.47	BAY-O-NET	3.709	48.30%	VIOLATION	2.478	-0.9%	Warning
T7110-FUSE	12.47	BAY-O-NET	3.549	42.00%	VIOLATION	N/A	N/A	N/A
T7115-FUSE	12.47	BAY-O-NET	3.523	40.90%	VIOLATION	N/A	N/A	N/A
T7116-FUSE	12.47	BAY-O-NET	3.601	2.90%	VIOLATION	N/A	N/A	N/A
T7117-FUSE	12.47	BAY-O-NET	3.485	39.40%	VIOLATION	N/A	N/A	N/A
T7206 IN	12.47	BAY-O-NET	3.439	37.60%	VIOLATION	2.264	-9.4%	Warning
T7218B-FUSE	12.47	BAY-O-NET	3.056	22.30%	VIOLATION	N/A	N/A	N/A
T7219A-FUSE	12.47	BAY-O-NET	3.016	20.60%	VIOLATION	N/A	N/A	N/A
T7230-FUSE	12.47	BAY-O-NET	3.472	38.90%	VIOLATION	N/A	N/A	N/A
T7237-FUSE	12.47	BAY-O-NET	3.772	50.90%	VIOLATION	2.373	-5.1%	Warning
T7238-FUSE	12.47	BAY-O-NET	3.841	53.60%	VIOLATION	2.48	-0.8%	Warning
T7298-FUSE	12.47	BAY-O-NET	3.798	8.50%	VIOLATION	N/A	N/A	N/A
T7301-FUSE	12.47	BAY-O-NET	3.533	41.30%	VIOLATION	N/A	N/A	N/A
T7302-FUSE	12.47	BAY-O-NET	3.452	38.10%	VIOLATION	N/A	N/A	N/A
T7316A-FUSE	12.47	BAY-O-NET	2.754	10.10%	VIOLATION	N/A	N/A	N/A
T7316B-FUSE	12.47	BAY-O-NET	2.736	9.40%	VIOLATION	N/A	N/A	N/A
T7318A IN	12.47	BAY-O-NET	2.972	18.90%	VIOLATION	N/A	N/A	N/A
T7339-FUSE	12.47	BAY-O-NET	3.346	33.80%	VIOLATION	N/A	N/A	N/A
T7340-FUSE	12.47	BAY-O-NET	2.661	6.40%	VIOLATION	N/A	N/A	N/A
T8001-F	12.47	BAY-O-NET	3.336	33.40%	VIOLATION	N/A	N/A	N/A
T8006 IN	12.47	BAY-O-NET	3.417	36.70%	VIOLATION	N/A	N/A	N/A
T8006-FUSE	12.47	BAY-O-NET	3.417	36.70%	VIOLATION	N/A	N/A	N/A
T8007 IN	12.47	BAY-O-NET	3.367	34.70%	VIOLATION	N/A	N/A	N/A
T8008 IN	12.47	BAY-O-NET	3.399	36.00%	VIOLATION	N/A	N/A	N/A
T8008-FUSE	12.47	BAY-O-NET	3.399	36.00%	VIOLATION	N/A	N/A	N/A
T8011 IN	12.47	BAY-O-NET	3.364	34.60%	VIOLATION	N/A	N/A	N/A
T8011-FUSE	12.47	BAY-O-NET	3.364	34.60%	VIOLATION	N/A	N/A	N/A
T8013-FUSE	12.47	BAY-O-NET	2.868	14.70%	VIOLATION	N/A	N/A	N/A
T8015-FUSE	12.47	BAY-O-NET	3.098	23.90%	VIOLATION	N/A	N/A	N/A
T8020-FUSE	12.47	BAY-O-NET	2.604	4.20%	VIOLATION	N/A	N/A	N/A
T8030 IN	12.47	BAY-O-NET	3.103	24.10%	VIOLATION	N/A	N/A	N/A
T8031-FUSE	12.47	BAY-O-NET	2.981	19.20%	VIOLATION	N/A	N/A	N/A
T8040A-FUSE	12.47	BAY-O-NET	2.717	8.70%	VIOLATION	N/A	N/A	N/A

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T8040B IN	12.47	BAY-O-NET	2.681	7.20%	VIOLATION	N/A	N/A	N/A
T8080A-FUSE	12.47	BAY-O-NET	3.242	29.70%	VIOLATION	N/A	N/A	N/A
T8118 IN	12.47	BAY-O-NET	2.566	2.60%	VIOLATION	N/A	N/A	N/A
T8140-FUSE	12.47	BAY-O-NET	3.174	27.00%	VIOLATION	N/A	N/A	N/A
T8150 IN	12.47	BAY-O-NET	3.086	23.40%	VIOLATION	N/A	N/A	N/A
T8202A-F	12.47	BAY-O-NET	3.004	20.20%	VIOLATION	N/A	N/A	N/A
T9018 IN	7.2	BAY-O-NET	4.725	89.00%	VIOLATION	4.725	89.0%	VIOLATION
T9018-FUSE	7.2	BAY-O-NET	4.725	89.00%	VIOLATION	4.725	89.0%	VIOLATION
T9024-FUSE	12.47	BAY-O-NET	3.71	48.40%	VIOLATION	2.683	7.3%	VIOLATION
T9045-FUSE	12.47	BAY-O-NET	6.758	170.30%	VIOLATION	6.984	179.4%	VIOLATION
T9097-FUSE	12.47	BAY-O-NET	4.541	81.70%	VIOLATION	3.304	32.1%	VIOLATION
T9109-FUSE	12.47	BAY-O-NET	4.025	15.00%	VIOLATION	N/A	N/A	N/A
T9110-FUSE	12.47	BAY-O-NET	4.032	61.30%	VIOLATION	2.645	5.8%	VIOLATION
T9114B-FUSE	12.47	BAY-O-NET	3.556	1.60%	VIOLATION	N/A	N/A	N/A
T9142-FUSE	12.47	BAY-O-NET	2.805	12.20%	VIOLATION	N/A	N/A	N/A
T9153A IN	12.47	BAY-O-NET	4.839	93.60%	VIOLATION	3.804	52.2%	VIOLATION
T9169-FUSE	12.47	BAY-O-NET	2.777	11.10%	VIOLATION	N/A	N/A	N/A
T9305-FUSE	12.47	BAY-O-NET	6.075	143.00%	VIOLATION	5.485	119.4%	VIOLATION
T9320 IN	7.2	BAY-O-NET	6.335	153.40%	VIOLATION	6.335	153.4%	VIOLATION
T9329-FUSE	12.47	BAY-O-NET	6.001	140.00%	VIOLATION	5.365	114.6%	VIOLATION
T9330 PRI	12.47	BAY-O-NET	4.894	95.80%	VIOLATION	3.832	53.3%	VIOLATION
T11955A-FUSE	12.47	BAY-O-NET	4.157	18.80%	VIOLATION	3.322	-5.1%	Warning
T11955B-FUSE	12.47	BAY-O-NET	4.123	17.80%	VIOLATION	3.215	-8.1%	Warning
T11981-FUSE	12.47	BAY-O-NET	3.567	42.70%	VIOLATION	2.697	7.9%	VIOLATION
T-36A-FUSE	7.2	BAY-O-NET	3.342	-4.50%	Warning	3.342	-4.5%	Warning
T-89-FUSE	7.2	BAY-O-NET	3.467	-0.90%	Warning	3.467	-0.9%	Warning
T-RAMP5 IN	12.47	BAY-O-NET	2.42	-3.20%	Warning	N/A	N/A	N/A
T-RAMP7 IN	12.47	BAY-O-NET	2.448	-2.10%	Warning	N/A	N/A	N/A
T1-1-FUSE	7.2	BAY-O-NET	3.182	-9.10%	Warning	3.182	-9.1%	Warning
T1-2-FUSE	7.2	BAY-O-NET	3.232	-7.70%	Warning	3.232	-7.7%	Warning
T1-3-FUSE	7.2	BAY-O-NET	3.289	-6.00%	Warning	3.289	-6.0%	Warning
T1-4-FUSE	7.2	BAY-O-NET	3.372	-3.60%	Warning	3.372	-3.6%	Warning
T1-5-FUSE	7.2	BAY-O-NET	3.456	-1.30%	Warning	3.456	-1.3%	Warning
T1-14-FUSE	7.2	BAY-O-NET	3.496	-0.10%	Warning	3.496	-0.1%	Warning
T1-15-FUSE	7.2	BAY-O-NET	3.403	-2.80%	Warning	3.403	-2.8%	Warning

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
T1-16-FUSE	7.2	BAY-O-NET	3.357	-4.10%	Warning	3.357	-4.1%	Warning
T1-35-FUSE	7.2	BAY-O-NET	3.202	-8.50%	Warning	3.202	-8.5%	Warning
T1-36-FUSE	7.2	BAY-O-NET	3.262	-6.80%	Warning	3.262	-6.8%	Warning
T1-37-FUSE	7.2	BAY-O-NET	3.312	-5.40%	Warning	3.312	-5.4%	Warning
T1-38-FUSE	7.2	BAY-O-NET	3.427	-2.10%	Warning	3.427	-2.1%	Warning
T1-39-FUSE	7.2	BAY-O-NET	3.165	-9.60%	Warning	3.165	-9.6%	Warning
T1-40-FUSE	7.2	BAY-O-NET	3.254	-7.00%	Warning	3.254	-7.0%	Warning
T1-41-FUSE	7.2	BAY-O-NET	3.292	-5.90%	Warning	3.292	-5.9%	Warning
T1-42-FUSE	7.2	BAY-O-NET	3.371	-3.70%	Warning	3.371	-3.7%	Warning
T1-43-FUSE	7.2	BAY-O-NET	3.455	-1.30%	Warning	3.455	-1.3%	Warning
T1-51-FUSE	7.2	BAY-O-NET	3.476	-0.70%	Warning	3.476	-0.7%	Warning
T1-52-FUSE	7.2	BAY-O-NET	3.379	-3.50%	Warning	3.379	-3.5%	Warning
T1-53-FUSE	7.2	BAY-O-NET	3.254	-7.00%	Warning	3.254	-7.0%	Warning
T1-55-FUSE_A	7.2	BAY-O-NET	3.177	-9.20%	Warning	3.177	-9.2%	Warning
T1-59-FUSE	7.2	BAY-O-NET	3.276	-6.40%	Warning	3.276	-6.4%	Warning
T5-3-FUSE	7.2	BAY-O-NET	3.444	-1.60%	Warning	3.444	-1.6%	Warning
T5-4-FUSE	7.2	BAY-O-NET	3.453	-1.40%	Warning	3.453	-1.4%	Warning
T5-5-FUSE	7.2	BAY-O-NET	3.303	-5.60%	Warning	3.303	-5.6%	Warning
T5-6-FUSE	7.2	BAY-O-NET	3.271	-6.60%	Warning	3.271	-6.6%	Warning
T5-7-FUSE	7.2	BAY-O-NET	3.177	-9.20%	Warning	3.177	-9.2%	Warning
T5-8-FUSE	7.2	BAY-O-NET	3.156	-9.80%	Warning	3.156	-9.8%	Warning
T4216-FUSE	12.47	BAY-O-NET	3.406	-2.70%	Warning	N/A	N/A	N/A
T4300-FUSE	12.47	BAY-O-NET	3.28	-6.30%	Warning	N/A	N/A	N/A
T4309B IN	7.2	BAY-O-NET	2.268	-9.30%	Warning	2.268	-9.3%	Warning
T5003A-FUSE	12.47	BAY-O-NET	3.214	-8.20%	Warning	N/A	N/A	N/A
T5004A-FUSE	12.47	BAY-O-NET	3.249	-7.20%	Warning	N/A	N/A	N/A
T5224A-FUSE	12.47	BAY-O-NET	2.347	-6.10%	Warning	N/A	N/A	N/A
T5262-F	12.47	BAY-O-NET	2.474	-1.00%	Warning	N/A	N/A	N/A
T5270-FUSE_A	12.47	BAY-O-NET	2.489	-0.40%	Warning	N/A	N/A	N/A
T7215-FUSE	12.47	BAY-O-NET	3.22	-8.00%	Warning	N/A	N/A	N/A
T7216-FUSE	12.47	BAY-O-NET	3.267	-6.70%	Warning	N/A	N/A	N/A
T7312-FUSE	12.47	BAY-O-NET	3.326	-5.00%	Warning	N/A	N/A	N/A
T7409-F	12.47	BAY-O-NET	2.261	-9.50%	Warning	N/A	N/A	N/A
T9350-FUSE	12.47	BAY-O-NET	3.357	-4.10%	Warning	N/A	N/A	N/A
TR-61-FUSE	7.2	BAY-O-NET	3.328	-4.90%	Warning	3.328	-4.9%	Warning

EQUIPMENT ID	Base kV	Fuse Type	3 Phase Fault			Line - Ground Fault		
			½ Cycle	½ Cycle Percent	Status	½ Cycle	½ Cycle Percent	Status
TR-62-FUSE	7.2	BAY-O-NET	3.279	-6.30%	Warning	3.279	-6.3%	Warning
TR-63-FUSE	7.2	BAY-O-NET	3.23	-7.70%	Warning	3.23	-7.7%	Warning
TR-64-FUSE	7.2	BAY-O-NET	3.203	-8.50%	Warning	3.203	-8.5%	Warning
TR-69-FUSE	7.2	BAY-O-NET	3.324	-5.00%	Warning	3.324	-5.0%	Warning
TR-70-FUSE	7.2	BAY-O-NET	3.372	-3.70%	Warning	3.372	-3.7%	Warning
TR-71-FUSE	7.2	BAY-O-NET	3.427	-2.10%	Warning	3.427	-2.1%	Warning
TR-73-FUSE	7.2	BAY-O-NET	3.387	-3.20%	Warning	3.387	-3.2%	Warning
TR-74-FUSE	7.2	BAY-O-NET	3.344	-4.50%	Warning	3.344	-4.5%	Warning
TR-75-FUSE	7.2	BAY-O-NET	3.299	-5.80%	Warning	3.299	-5.8%	Warning
TR-76-FUSE	7.2	BAY-O-NET	3.257	-7.00%	Warning	3.257	-7.0%	Warning
TR-77-FUSE	7.2	BAY-O-NET	3.207	-8.40%	Warning	3.207	-8.4%	Warning
TR-78-FUSE	7.2	BAY-O-NET	3.186	-9.00%	Warning	3.186	-9.0%	Warning
TR-79-FUSE	7.2	BAY-O-NET	3.271	-6.50%	Warning	3.271	-6.5%	Warning
TR-80-FUSE	7.2	BAY-O-NET	3.322	-5.10%	Warning	3.322	-5.1%	Warning
TR-81-FUSE	7.2	BAY-O-NET	3.373	-3.60%	Warning	3.373	-3.6%	Warning
TR-82-FUSE	7.2	BAY-O-NET	3.426	-2.10%	Warning	3.426	-2.1%	Warning
TR-83-FUSE	7.2	BAY-O-NET	3.265	-6.70%	Warning	3.265	-6.7%	Warning
TR-84-FUSE	7.2	BAY-O-NET	3.228	-7.80%	Warning	3.228	-7.8%	Warning
TR-90-FUSE	7.2	BAY-O-NET	3.333	-4.80%	Warning	3.333	-4.8%	Warning

Note: Short circuit violations are any device where the available fault current is higher than the Short Circuit rating of the device (i.e., overduty). A warning would be any device that is within 10% of being overdutied.

7

ARC FLASH ANALYSIS



Section 7 provides a summary of the EasyPower arc flash analysis results. Comprehensive graphical and text reports containing arc flash information for all system buses are readily available from the EasyPower model.

7.1 Purpose of Arc Flash Analysis

The nature of arcing equipment failures and the rate of serious burn injuries in the electrical industry led the NFPA to develop arc flash electrical safety guidelines in NFPA 70E, *Electrical Safety in the Workplace*, for work on or near energized electrical equipment. IEEE 1584 provides guidance regarding how to assess arc flash.

For the Air Force, additional criteria related to arc flash hazards are provided in the following documents:

- AFMAN 32-1065, *Grounding & Electrical Systems*.
- UFC 3-560-01, *Electrical Safety, O&M*.
- ESA – EasyPower IEC Systems Incident Energy Calculation Method.

An arc flash analysis typically accomplishes the following:

- Calculates arc flash incident energy levels at key locations throughout the system.
- Provides basis for personal protective equipment (PPE) requirements based on arc flash analysis results for specific work locations.
- Identifies potential equipment line-ups or protective device setting changes that can reduce the arc flash hazard at specific locations.
- Identifies locations in which energized work cannot be conducted safely regardless of available PPE due to exceptionally high arc flash energy levels.
- Considers whether the upstream overcurrent protective device can perform its safety function of clearing the fault based on past maintenance and testing, as applicable.

The purpose of conducting an arc flash study is to define the arc flash hazard associated with energized electrical work so that workers can select and wear the appropriate PPE for the anticipated energized work hazard. PPE categories are specified in NFPA 70E. Table 7-1 lists the

typical PPE clothing given the specified arc flash incident energy levels; additional PPE requirements are provided in NFPA 70E and UFC 3-560-01.

**Table 7-1
Selection of Arc-Rated Clothing and Other PPE -
When the Incident Energy Analysis Method Is Used**

Incident energy exposures equal to 1.2 cal/cm² up to 12 cal/cm²

Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy^a

Long-sleeve shirt and pants or coverall or arc flash suit (SR)

Arc-rated face shield and arc-rated balaclava or arc flash suit hood (SR)^b

Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)

Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)^c

Hard hat

Safety glasses or safety goggles (SR)

Hearing protection

Leather footwear

Incident energy exposures greater than 12 cal/cm²

Arc-rated clothing with an arc rating equal to or greater than the estimated incident energy^a

Long-sleeve shirt and pants or coverall or arc flash suit (SR)

Arc-rated arc flash suit hood

Arc-rated outerwear (e.g., jacket, parka, rainwear, hard hat liner) (AN)

Arc-rated gloves or rubber insulating gloves with leather protectors (SR)^c

Hard hat

Safety glasses or safety goggles (SR)

Hearing protection

Leather footwear

SR: Selection of one in group is required.

AN: As needed.

^aArc ratings can be for a single layer, such as an arc-rated shirt and pants or a coverall, or for an arc flash suit or a multi-layer system if tested as a combination consisting of an arc-rated shirt and pants, coverall, and arc flash suit.

^bFace shields with a wrap-around guarding to protect the face, chin, forehead, ears, and neck area are required by 130.7(C)(10)(c). Where the back of the head is inside the arc flash boundary, a balaclava or an arc flash hood shall be required for full head and neck protection.

^cRubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.

7.2 Arc Flash Analysis Basics

Arc flash hazard studies require knowledge of both the electrical power system and the system's electrical protection. Arc flash studies can be considered a continuation of the short circuit and coordination analysis of a power system, since the results of each are required to determine the incident energy associated with an arc flash event at any specific location in the power system. Numerous design and configuration factors can affect the calculated arc flash energy levels. For this reason, development of the electrical analysis model for the purpose of arc flash calculations requires a level of detail.

The Arc flash boundary and associated protection requirements are based on the incident energy levels available to the person's chest or face, not the hands or arms. The degree of injury depends on the percentage of the person's skin that is burned, and the degree of the burn.

7.3 Interpreting Arc Flash Analysis Results

Arc flash analysis results can be viewed directly on the EasyPower one-line diagram; a typical EasyPower arc flash display is shown in Figure 7-1. Analysis parameters are set by the user and include many options. Recommended analysis settings are discussed in Section 7.4.

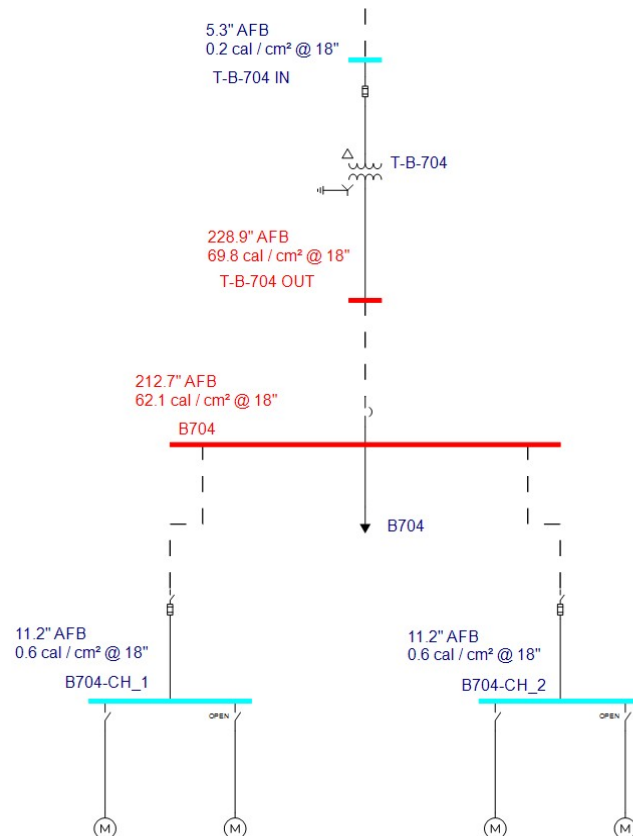


Figure 7-1
Typical EasyPower Arc Flash Result

Referring to Figure 7-1, the interpretation of a typical EasyPower arc flash display is as follows:

- The arc flash value on the primary side of distribution transformer T-B-704 is 0.2 cal/cm². Accordingly, if not able to de-energize equipment the PPE requirements are for under 1.2 cal/cm² for this location.
- The arc flash value for the secondary of Transformer T-B-704 is 69.8 cal/cm², which exceeds the arc flash threshold incident energy of 1.2 cal/cm². In article 130.5(c) NFPA 70E 2018 suggests that only after all other risk control have been exhausted should PPE be selected.

- The arc flash value at the service entrance of Building 704 is 62.1 cal/cm², which exceeds the arc flash threshold incident energy of 1.2 cal/cm². In article 130.5(c) NFPA 70E 2018 suggests that only after all other risk control have been exhausted should PPE be selected.

The EasyPower arc flash analysis provides additional information in its arc flash spreadsheet. Figure 7-2 shows an example of this display.

Arc Flash Hazard Report for 'Protection-1 (Base Case)'															
Arc Fault Bus Name	Arc Fault Bus kV	Upstream Trip Device Name	Upstream Trip Device Function	Equip Type	Electrode Configuration	Electrode Gap (mm)	Bus Bolted Fault (kA)	Bus Arc Fault (kA)	Trip Time (sec)	Opening Time (sec)	Arc Time (sec)	Est Arc Flash Boundary (inches)	Working Distance (inches)	Incident Energy (cal/cm2)	Comments
B704-CH_1	0.208	F1-A		Int Switch	VCB	32	19.884	7.481	0.045	0	0.045	11.2	18	0.6	

Figure 7-2
Typical EasyPower Arc Flash Spreadsheet

The following is a brief description of the report headings for the Arc Flash Risk Assessment report.

- Arc Fault Bus Name:** This is the ID Name of the buses faulted. You can have single or multiple (including all buses) faulted for arc flash analysis. MCC and panel schedules also are presented as buses; this represents the main bus within the MCC or panel.
- Arc Fault Bus kV:** The voltage of the bus being faulted.
- Upstream Trip Device Name:** When a bus is faulted, EasyPower checks every protective device for the current contribution to the fault. If the current passing through the protective device is significant, then the results corresponding to the trip time of that device are provided in the spreadsheet.
- Upstream Trip Device Function:** If the trip device is a relay, then the device function name is provided in this column. Examples of device functions are: 51/50, 51N, 50G, 49, etc.
- Equipment Type:** Describes the type of enclosure specified in the Bus Data. The available types are inclusive of Switchgear, MCC/Panel, Open Air and Conductor.
- Electrode Configuration:** The electrode configuration on which the arc flash calculations are based. This considers whether the conductors are in an enclosure or in open air, as well as the orientation of the conductors and whether they terminate into an insulated barrier. This comes from the device library, or it can be specified by the user in the equipment data.
- Electrode Gap:** Gap between the phase conductors. This comes from the device library, or it can be specified by the user in the equipment data. The gap can be specified according to enclosure type and voltage. It is always expressed in millimeters.
- Bus Bolted Fault (kA):** This is the total bolted fault current calculated at the faulted bus.
- Bus Arc Fault (kA):** This is the total arcing current calculated at the faulted bus.
- Trip Time (sec):** Trip time for the protective device at the estimated arc current.

- **Opening Time (sec):** Opening time for HV breakers or opening device after the relay trips. This column is applicable only for relays. After the relay trips, the HV breaker takes this amount of time to clear the fault. If the trip device is a fuse or LV breaker instead of a relay, the trip time already includes the opening time so this column will be blank. There are some exceptions that apply. Some relays already include the breaker opening time in their trip curves. These are referred to as “SST Relays”. Examples are Cutler-Hammer Digitrip 1150V, Digitrip MCV, etc. The opening time from the dialog of the switching device will be used. If the ID name of the switching device is not specified, the opening time of the breaker right next to the relay will be used. If there are no immediate switching devices, the program will traverse upstream to find the first switching device.
- **Arc Time (sec):** Total duration of arc fault. This is the sum of Trip Time and Opening Time. If an Aux Time is specified in the relay dialog, the Arc Time includes aux time, trip time, and opening time.
- **Estimated Arc Flash Boundary:** The flash protection boundary distance in specified units. This value corresponds to the trip device.
- **Working Distance:** Approximate working distance in specified units. You can specify up to five different working distances in Short Circuit Options. For each working distance, the incident energy will be calculated.
- **Incident Energy (cal/cm²):** This is the incident energy from arc flash corresponding to the trip device. The trip time associated with the trip device is used in the calculation. However, the arc current or fault current used is the total fault current on the faulted bus and not the current seen by the trip device. The rating of personal protective equipment (PPE) worn by workers should be based on this value.
- **Comment:** Comments generated by EasyPower—for example, "No Valid Trip Device Found Upstream or in Bus Dialog," "Do not Work on Energized Equipment," or "Out of IEEE 1584-2018 Range."

7.4 Arc Flash Analysis Parameters

When conducting an arc flash analysis, the user must define several parameters. There are not “right” or “wrong” selections for these settings. Rather, the settings are dependent upon the circumstances of the analysis and what specific information the user is trying to obtain. Within EasyPower, the arc flash analysis parameters are set within the *Short Circuit Options* dialog box, shown in Figure 7-3.

Short Circuit Options

Control

Text Output

One-line Output

Arc Flash Hazard

Customize Arc Flash control settings.

Standard: IEEE 1584-2018

Worst-Case Arc Flash Hazards Output: Including Main

Max Times (sec)

< 0.25 kV:	0.25 to 1 kV:	> 1 kV:
2	2	2

Create Report

☒ Arc Flash Spreadsheet

☐ Arc Flash Threshold

Calculate Arc Flash Using: Integrated

Display Incident Energy in: cal/cm2

Display Working Distance in: Inches

Working Distances (Below) Apply to: Enclosed

kV	Threshold Incident Energy (cal/cm2)	Default Working Distances (Inches)			
0.1 - 0.3	12	18	24	36	
0.1 - 0.3 (Switchgear)	12	18	24	36	
0.3 - 0.75	12	18	24	36	
0.3 - 0.75 (Switchgear)	12	18	24	36	
0.75 - 5	12	18	24	36	
5 - 15	12	18	24	36	
15 - 36	12	31	36	48	

Advanced...

Default... OK Cancel Apply Help

Figure 7-3
Arc Flash Analysis User Settings Dialog Box

The various analysis parameters and the settings used for an arc flash analysis are described below:

- Standard** – Options include EasyPower specific methods, NFPA 70E, and IEEE 1584. IEEE 1584 is recommended as the basis for any calculations and the analysis results are based on IEEE 1584. With a detailed model, the IEEE computations should provide the most realistic values. The NFPA 70E method is based on low voltage applications and is overly conservative for medium voltage analyses. NFPA 70E recognizes IEEE 1584 as an acceptable approach for conducting the calculations.
- Worst-Case Arc Flash Hazards** – This is one of the most important and useful fields for conducting arc flash calculations. Output results for main buses can be produced with or without the main bus incoming breaker included in the calculation. Additionally, an option exists to provide “detailed” output results, which provide arc flash quantities downstream of the bus feeder breakers. When ‘Worst Case’ branch circuit cubicle labels are used, separate unique labels must still be applied to any cubicles housing the equipment’s main overcurrent device(s) or tie breakers. Any ‘Worst Case’ branch circuit cubicle labels should be conspicuously located on the equipment and should contain wording which clearly indicates which cubicles the label applies to.
- Max Times** – User defined times are specified to establish maximum arcing times for the different voltage classes. The values established for this analysis are based on engineering judgment for the voltage levels involved. These values will generally not influence the analysis results when the arc flash values are based upon the time-current response time of upstream protective devices.

- **Calculating Arc Flash Using** – When determining arc flash values associated with personnel safety, it is generally advisable to use Momentary current, which is the default setting.
- **Display Incident Energy in:** You can specify whether you want incident energy displayed in calories or joules per square centimeter.
- **Display Working Distance in–** Working distances can be specified in different units. This analysis specifies working distances in inches. EasyPower provides up to six working distances for each voltage level. This allows the user to adjust distances based on the tasks of interest. Default working distances can be changed for enclosed and open-air circumstances. This analysis uses the EasyPower default working distances, which are generally appropriate for typical tasks that do not involve live-line tools. There may, however, be times when the default worst-case distance is not appropriate. For example, if an operation is being conducted using a 6-foot hot stick, the arc flash PPE requirements can be based on the known working distance and not the default worst-case distance.
- **Working Distances (Below) Apply to:** You can specify separate working distances for open air and enclosed space. Select the appropriate choice to view or edit the values in the spreadsheet. Typically for medium voltage, switches and fuses in open air may be operated from a greater distance.
- **Create Report:**
 - **Arc Flash Threshold:** Check this box to obtain a report of buses that exceed the arc flash threshold incident energies specified in the options. You can specify any incident energy as the threshold for various voltage levels by typing in the values in the spreadsheet in the Arc Flash Hazard options. All equipment exceeding the hazard thresholds will be displayed in red on the one-line.
 - **Threshold Incident Energy:** For every voltage level you can specify the threshold incident energy. Equipment with incident energies exceeding the threshold values will be highlighted in red in the one-line output and they will be reported in the Arc Flash Threshold Report. This provides instant notification of a danger condition. All equipment with incident energies exceeding the threshold values are displayed in red on the one-line.

7.5 Practical Considerations

An arc flash analysis determines the incident energy at a specified location and the required PPE is selected for working on energized electrical equipment at that location. Several items should be carefully considered with respect to this simple statement:

- AFMAN 32-1065 and UFC 3-560-01 clearly state that working on or near energized electrical equipment is prohibited except in rare circumstances, and then only when justified and approved by the BCE or equivalent in accordance with the criteria established in these documents. For most day-to-day work activities, the results of an arc flash analysis should not be needed because the work will be performed on deenergized equipment.

AFMAN 32-1065 clarifies the energized work criteria for primary distribution with the following statements:

Work on or near energized overhead distribution lines is prohibited except in rare circumstances and then only when approved by the BCE or equivalent in accordance with procedures outlined in the following paragraphs. Authorization is not required for tasks such as voltage measurement or phasing tests, as long as maintenance or repair is not performed and safe practices and appropriate PPE are used.

Conventional circuit de-energizing/re-energizing methods (i.e., turning off/on a switch, opening and closing hook switches, or operating circuit breakers/disconnects) for the purpose of isolating circuits needing work are not considered performing “maintenance on energized circuits,” and consequently do not require BCE approval; however, proper PPE shall be used when performing de-energizing/re-energizing procedures.

- The PPE requirements are based on working on or near energized exposed electrical equipment. If the equipment is deenergized, then the PPE requirements do not apply.

Note: UFC 3-560-01 specifies minimum PPE requirements for qualified electrical workers regardless of any arc flash result.

- The calculated incident energy depends on how long it takes an upstream protective device to sense, respond to, and eventually clear the arcing fault. If the upstream protective device is a set of fuses, they likely will respond as intended. If the upstream protective device is a circuit breaker that has not been tested or maintained, there is no assurance whatsoever that it will respond as intended.
- Even if the trip device is functional, can the circuit breaker actually open? Has it ever been operated? For medium voltage and low voltage power circuit breakers, has the lubricant hardened or have any required moving parts broken? Once again, it is hard to envision taking credit for an arc flash analysis on a system that has received little or no periodic maintenance.

“The arc flash hazard analysis shall take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance.”

- The EasyPower arc flash settings in the *Short Circuit Options* dialog box are critical to consider. In particular, an arc flash analysis intended to allow energized work on a service entrance panel must determine whether credit can be taken for the main service disconnect.
- All calculated arc flash incident energy levels should be considered only a best estimate of the available arc fault energy and calculated on the conservative side with respect to personnel safety requirements.
- An EasyPower arc flash result of “**Extreme Danger**” means that the calculated energy is greater than 40 cal/cm². One approach suggested for these locations is to purchase flash protection suits rated for 65 cal/cm², 100 cal/cm², or maybe even 140 cal/cm². An arc flash suit provides

thermal protection from an arcing fault event; it is not certified to provide blast protection. An arc flash result of “Extreme Danger” means that the equipment must be deenergized before work is allowed.

- One approach used to improve arc flash results for a specific work task is to add in devices that reduce the arc flash incident energy. These devices are commonly referred to as an energy reduction solution (such as: maintenance mode or reduced energy let through (RELT)).

The recommended method for evaluating arc flash requirements for a specific work location and setup is by the EasyPower model. Refer to UFC 3-560-01 for arc flash criteria and personal protective equipment (PPE) requirements for energized line work. Refer also to Engineering Technical Letter (ETL) 06-1, *Arc Flash Personal Protective Equipment (PPE) Requirements for High-Voltage Overhead Line Work at 69 kV (Nominal) or Less*, which emphasizes that “Working on energized electrical equipment is prohibited except in rare circumstances, and then only when justified and approved by the BCE or equivalent in accordance with AFMAN 32-1065.”

The arc flash protective clothing requirements for energized work vary based on incident energy levels throughout the primary distribution system. Specifically, 1.2 to 12 cal/cm² and then above 12 cal/cm². Along the main portion of each feeder, the switching station relays are credited in the arc flash analysis as the protective devices that clear the arcing fault.

Although this power system analysis extends to the service entrance of each facility, the analysis is mainly an evaluation of the primary distribution system. Arc flash results for the service entrance panel of any facility should be applied with care. The model was prepared in a manner that allows the service entrance protective device (fuses or breaker) to be used in the arc flash calculations. These results only apply if the connections and buswork electrically upstream of the service entrance disconnect are not accessible while performing energized line work.

7.6 Arc Flash Labels

The following lists the types of arc flash label formats that have been approved within UFC 3-560-01 are adopted for use when labeling equipment.

7.6.1 Detail Arc Flash Label.

Where appropriate, provide detail arc flash labels in accordance with the format shown in Figure 7-4.

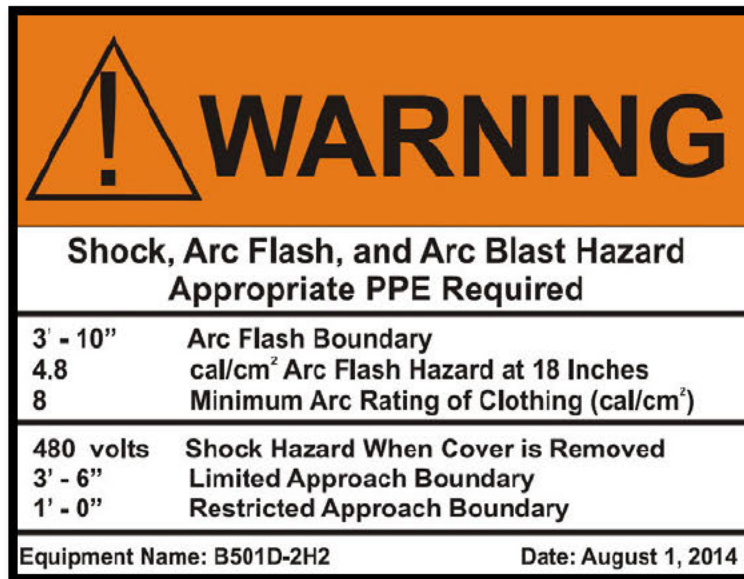


Figure 7-4
Typical Detail Arc Flash Label

For new and existing installations, a detailed label is only authorized if the Activity has an arc flash risk assessment program that includes documented periodic maintenance and testing. New installations must also have been commissioned in accordance with NETA Acceptance Test Specifications.

NFPA 70E specifies the following information to be included on a detailed arc flash label:

- Equipment identification number
- Date of arc flash calculation
- Nominal system voltage
- Arc flash boundary
- At least one of the following:
 - Available incident energy and the corresponding working distance, or the arc flash PPE category in NFPA 70E Table 130.7(C)(15)(a) or 130.7(C)(15)(b) for the equipment, but not both.
 - Minimum arc rating of clothing.
 - Site-specific level of PPE

7.6.2 Arc Flash Label, Existing Equipment Without Maintenance or Testing.

Where appropriate, provide “Existing Equipment Without Maintenance or Testing” arc flash labels in accordance with the format shown in Figure 7-5.



Figure 7-5
Existing Equipment Without Maintenance or Testing

Arc flash calculation results are based on proper operation of upstream protective devices in accordance with their published time-current curves. Periodic maintenance and testing of electrical equipment is essential to confirming this proper operation. Use the standard label provided in Figure 1-10 for the following equipment locations:

- New installations that did not include commissioning in accordance with NETA ATS.
- Existing installations without maintenance and testing in accordance with NETA MTS or NFPA 70B in the last five years.

7.6.3 Arc Flash Danger Label for Locations Identified to Be Greater Than 40 cal/cm².

Where appropriate, provide “Arc Flash Danger Label for Locations Identified to Be Greater Than 40 cal/cm²” arc flash labels in accordance with the format shown in Figure 7-6.



Figure 7-6

Arc Flash Danger Label for Locations Identified to Be Greater Than 40 cal/cm²

7.7 Arc Flash Analysis Results

7.7.1 Results

Table 7-2 provides the arc flash locations where incident energy exceeds 40 cal/cm² for low voltage buses. A detailed arc flash summary report is provided in Volume 2 Appendix L for the primary distribution system.

- Base Case – Utility Sourced: Existing protective device settings throughout the system.

Table 7-2 Base Case-Utility Sourced – Low Voltage Buses Greater than 40 cal/cm²

Arc Fault Bus Name	Arc Fault Bus kV	Incident Energy (cal/cm ²)
B5110B (M1) SE2 IN	0.48	40.4
B5110B (US C15) SE1 IN	0.48	40.4
B5110B (M2) SE4 IN	0.48	40.5
B5110B (M3) SE6 IN	0.48	40.5
B5110B (US C5) SE5 IN	0.48	40.5
B5110B (US C12) SE3 IN	0.48	40.5
B7106A (MLO)	0.208	40.7
B6112A IN	0.208	41
T7405 OUT	0.208	41.6
T7301 OUT	0.208	41.7
T7218A OUT	0.208	42.2
T5005A OUT	0.48	43.2
B7339 (H-1 DISC.) SE2 IN	0.48	44.4
T7000B OUT	0.48	44.5

Arc Fault Bus Name	Arc Fault Bus kV	Incident Energy (cal/cm2)
B8202B (HDP) IN	0.48	44.6
T7000A OUT	0.48	45.8
B5212 (MCC RIGHT) IN	0.48	46.2
T6112A OUT	0.208	46.3
B7234 IN	0.208	46.7
B7234 OUT	0.208	46.7
T5212 OUT	0.48	47.1
T8202B OUT	0.48	47.4
B7402 (MLO)	0.208	47.4
B7000B OUT	0.48	47.9
B6125B (PANEL M-5126) SE2 IN	0.208	47.9
B7000A IN	0.48	48
T7234 OUT	0.208	48.2
B7000B IN	0.48	48.7
B7000A OUT	0.48	48.9
T7402 OUT	0.208	49.5
T7220A OUT	0.208	49.8
B5225 SE2 IN	0.48	50.2
T5110A OUT	0.48	50.3
T6125B OUT	0.208	50.3
T5110B OUT	0.48	50.6
B7302 (SERVICE DISC.) SE1 OUT	0.208	50.8
T6030B OUT	0.48	51
B6030B IN	0.48	51.2
B6030B OUT	0.48	51.2
B5110A SE1 IN	0.48	52.3
B5110A SE1 OUT	0.48	52.3
T6137 OUT	0.208	52.3
B7008C (SWBD MA) IN	0.208	53.3
B7008C (SWBD MA) OUT	0.208	53.3
B8202A (LDP) IN	0.208	53.7
B7008A (MAIN) IN	0.208	53.8
B7008A (MAIN) OUT	0.208	53.8
T6136A OUT	0.208	54
T6030A OUT	0.48	54.2
B-EG1	0.48	54.4
B6030A IN	0.48	54.7
T5224B OUT	0.48	54.9
T7215 OUT	0.208	55
T8202A OUT	0.208	55.4
B5224B (MAIN NO.2) IN	0.48	56.5
B5224B (MAIN NO.2) OUT	0.48	56.5
B5225 (MSB) SE1 IN	0.48	57.1
T7008C OUT	0.208	57.1
T8011 OUT	0.208	57.1
B6030D (MS) IN	0.208	57.2

Arc Fault Bus Name	Arc Fault Bus kV	Incident Energy (cal/cm2)
T7302 OUT	0.208	57.6
B6138B SE1 (MDP) IN	0.208	58.1
T-EG1 SEC	0.48	58.3
T7008A OUT	0.208	58.3
T5225 OUT	0.48	58.4
B7302 (SERVICE DISC.) SE1 IN	0.208	58.6
T5224A OUT	0.48	59.2
T6030D OUT	0.208	60.9
B5224A (MAIN NO.1) IN	0.48	61
T6138B OUT	0.208	66.9
T7106B OUT	0.208	68.6
T-BESS SEC	0.48	72.8
T7106A OUT	0.208	75.1

Note: The model did not contain any medium voltage buses with incident energy greater than 12 cal/cm2 . Please refer to Volume 2 Appendix L for the full report.

The potential for upgrading the existing protective devices to units that provide an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)) is considered. These devices allow for the safe operation and work in and around high arc flash incident energy devices.

Refer to Section 9 for recommended relay settings and fuse sizing to reduce arc flash incident energy levels.

7.7.2 Periodic Maintenance and Testing

An arc flash PPE level depends in part on the expected clearing time of an upstream protective device. Maintenance and testing are both necessary to ensure a device is functional and can be credited by an arc flash study. With respect to circuit breakers, maintenance confirms that the circuit breaker can operate as designed and testing confirms that a trip signal will be initiated as designed. NFPA 70E-2018 addresses this by requiring:

“The arc flash hazard analysis shall take into consideration the design of the overcurrent protective device and its opening time, including its condition of maintenance.”

The term “condition of maintenance” refers to maintenance and testing of sufficient quality that the upstream protective device can be expected to operate as intended and within the analyzed operating time. For this primary distribution study, periodic maintenance and testing of the switching station circuit breakers and protective relays is necessary to use the arc flash results. Refer to Section 11 for recommendations regarding periodic maintenance and testing.

8

ELECTRICAL PROTECTION AND COORDINATION CRITERIA

Section 8 provides the criteria applied to this power system study. Proper electrical protection and coordination are essential for electrical distribution system reliability. The fundamental objectives of system protection are to:

- Rapidly isolate an unwanted electrical event faulted circuit at the closest possible point upstream of the fault, while minimizing disruptions to unaffected portions of the system.
- Mitigate and Minimize damage to the impacted circuit or equipment by rapidly removing it from service.
- Mitigate and Minimize the possibility of damage to equipment upstream of the fault that “sees” the fault current but is otherwise unaffected.
- Mitigate and Minimize the possibility of catastrophic equipment failure, fire, and personnel hazards.

Ideally, the protection scheme design is fully coordinated. A fully coordinated system accomplishes the above objectives over the entire range of possible fault currents. A partially coordinated system has gaps in coverage, i.e., coordination is achieved only for a portion of the fault current range. Lack of coordination can result in undesired protective action and the unnecessary removal from service of portions of the distribution system.

8.1 Scope of Electrical Coordination Review

This study represents a review of the primary distribution system, which starts at the substation. The scope of the coordination review extends throughout the primary / low voltage distribution system. The following summarizes the analysis scope:

- Protection and coordination along the primary distribution system were evaluated.
- Because the electrical model typically stops at the facility service entrance disconnect, the coordination criteria applied to low voltage equipment within a facility consisted of a confirmation that it cannot cause the complete loss of a primary distribution feeder for the defined settings or size.

- Branch breakers downstream of the service entrance disconnect are not included in the scope of this analysis. The EasyPower model provides the starting point for the modeling of individual facilities, if needed.

8.2 Electrical Protection and Coordination Criteria

Electrical coordination was evaluated using standard industry methods and criteria. Time-current coordination plots were developed for the system. The time-current curves for related devices are graphically depicted on a common plot. The curves are then compared using the specified criteria to confirm that the nearest protective device upstream from the fault will open before other upstream devices. This comparison is made over the possible fault current range. The postulated fault current ranges from a very light overload at the low end up to the maximum predicted fault current for the fault location (based on short circuit study values). The maximum predicted fault current represents the worst-case 3-phase momentary asymmetrical fault current (line faults) or worst-case line-to-ground momentary asymmetrical fault current (ground faults). Table 8-1 provides the criteria applied in this evaluation.

Table 8-1
Desired Electrical Protection and Coordination Criteria

Upstream Device	Downstream Device	Criteria
TOC Relay or Recloser	TOC Relay	A minimum margin of 0.4 seconds between TC curves in the TOC region. No overlap between the TC curves for instantaneous elements with 10% margin.
TOC Relay or Recloser	Switchgear Breaker, Fuse, and MCCB	A minimum margin of 0.3 seconds between the TC curve and the switchgear breaker/MCCB/fuse curve in the TOC region. No overlap between the TC curves for instantaneous elements with 10% margin.
Switchgear Breaker	Switchgear Breaker	No overlap between TC curves. All tolerances are accounted for in the curves.
Switchgear Breaker	MCCB	No overlap between TC curves. All tolerances are accounted for in the curves.
MCCB	MCCB	No overlap between TC curves. All tolerances are accounted for in the curves.
MCCB	Fuse (Non-Current Limiting)	Total clearing time of fuse must be below the minimum trip time of breaker in the TOC region. Alternatively, the fuse average clearing time must be below the minimum trip time of breaker with 10% margin. Maximum fault current sensed by MCCB must be limited to below the MCCB instantaneous pickup.
MCCB	Fuse (Current Limiting)	Total clearing time of fuse must be below the minimum trip time of breaker in the TOC region. Alternatively, the fuse average clearing time must be below the minimum trip time of the breaker by a 10% margin. Peak let-through current of fuse must be below the MCCB instantaneous pickup.

Upstream Device	Downstream Device	Criteria
Fuse	Fuse	Total clearing time of downstream fuse must be below the minimum melt time of upstream fuse. Alternatively, the average clearing times of the fuses must not overlap with a 10% margin applied to each fuse. Alternatively, the I^2t of the downstream fuse must be lower than the I^2t of the upstream fuse. The I^2t requirement is considered satisfied if fuse manufacturer's selectivity ratio is maintained.
Fuse	MCCB	No overlap between MCCB TC curve and minimum melt time curve for fuse. Alternatively, there is no overlap between MCCB TC curve and average clearing time curve for fuse with 10% margin. No coordination above intersection of fuse TC curve and MCCB instantaneous curve.
Transformers		Protective device must clear the fault before the transformer damage curve is exceeded. Conservatively use frequent fault damage curves. Upstream protective device setting must allow for transformer inrush without nuisance trip.
Cables		Protective device must clear the fault before cable I^2t damage curve is exceed.

8.3 Conductor Protection

IEEE 242-2001 is used as the principal reference for conductor protection for short circuit current considerations. As an example, Figure 8-1 shows conductor short circuit capability as a function of conductor size. The curves provided here are based on an initial conductor temperature of 75°C and a final conductor temperature of 200°C. The x-axis scale is 10x.

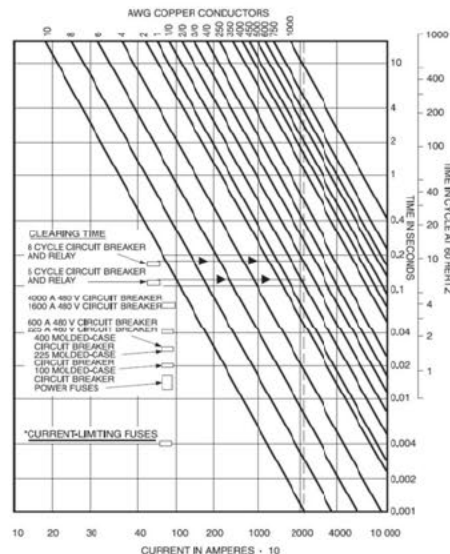


Figure 8-1
Maximum Short-Circuit Current for Insulated Copper Conductors

9

ELECTRICAL PROTECTION AND COORDINATION – RECOMMENDED RELAY SETTINGS

Section 9 provides the existing coordination and sequence of As Found & Recommended relay settings where recommendations are provided. A complete set of TCC plots for As Found and Recommended are provided in Appendix M.

9.1 Operational Relay Settings

Coordination issues are moderate at this facility, most issues could be rectified with setting adjustments and fuse replacements. Additionally, there are several locations where arc flash could be lowered through settings adjustments or fuse replacements. Table 9-1 represents the recommended adjustments for coordination and/or arc flash.

Additionally, there are several locations where arc flash cannot be reduced through settings adjustments or fuse replacements. Subsequently, in other areas, cables need to be resized to comply with NEC 310.16. Table 9-2 outlines the recommended mitigation routes to address these issues.

Per the project work scope, time coordination curves for facilities listed as critical / mission critical are to be provided for As Found and Recommended. For completeness, all TCC curves have been provided to address this requirement. All TCC's are provided in Appendix M and any recommendations are provided in Section 9.2.

9.2 Recommended Equipment Setting Adjustments

The following issues have been identified with the existing settings:

Recommended Relay/Breaker settings and fuse resizing are provided in Table 9-1:

Table 9-1
Recommended Equipment Setting Adjustments

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
JB1-040	As Found	Yes	0.208	P-B1-L3-19 Kearney K 40	To better coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMRs.
JB1-040 Recommended	S1-Recommended	Update	0.208	P-B1-L3-19 Kearney K 80	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T4101	As Found	Yes	0.48	P-B1-L3-24 Kearney Fuse Links K 12	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
T4101 Recommended	S1-Recommended	Update	0.48	P-B1-L3-24 Kearney Fuse Links K 25	
T4230	As Found	Yes	0.48	P-B1-L5-4 Kearney Fuse Links K 50	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
T4230 Recommended	S1-Recommended	Update	0.48	P-B1-L5-4 Kearney Fuse Links K 65	
T4202	As Found	Yes	0.208	P-B1-L5-5 Kearney Fuse Links K 20	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.
T4202 Recommended	S1-Recommended	Update	0.208	P-B1-L5-5 Kearney Fuse Links K 12	
T4112	As Found	Yes	0.24	LVB-B4112 SQD M Frame MA Frame = 800A (600AT) Trip = 600 Inst = 4500 (4500A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T4112 Recommended	S1-Recommended	Update	0.24	LVB-B4112 SQD M Frame MA Frame = 800A (600AT) Trip = 600 Inst = Low (3000A)	
T-BOMBPAD	As Found	Yes	0.208	P-B4-35 Kearney Fuse Links K 6	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
T-BOMBPAD Recommended	S1-Recommended	Update	0.208	P-B4-35 Kearney Fuse Links K 8	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T9329	As Found	Yes	0.48	LVB-B9329 S3 GE Spectra RMS Frame = 600 Plug = 500 STPU = Max (2500A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (5060A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T9329 Recommended	S1-Recommended	Update	0.48	LVB-B9329 S3 GE Spectra RMS Frame = 600 Plug = 500 STPU = Min (750A) ST Delay = Fixed ST Delay I ² t = In Inst = Min (1520A)	
T6136B	As Found	Yes	0.48	FU-T6136B BAY Cooper Expulsion BAY-O-NET 10A FU-T6136B Cooper Current-Limit ELSP 30	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T6136B Recommended	S1-Recommended	Update	0.48	FU-T6136B BAY Cooper Expulsion BAY-O-NET 12A FU-T6136B Cooper Current-Limit ELSP 40	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7004A	As Found	Yes	0.208	FU-T7004A BAY Cooper Expulsion BAY-O-NET Current Sensing 15A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T7004A Recommended	S1-Recommended	Update	0.208	FU-T7004A BAY Cooper Expulsion BAY-O-NET Dual Element 15A	
T9350	As Found	Yes	0.48	FU-T9350 BAY Cooper Expulsion BAY-O-NET Current Sensing 10A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T9350 Recommended	S1-Recommended	Update	0.48	FU-T9350 BAY Cooper Expulsion BAY-O-NET Dual Sensing 8A	
T-LT22	As Found	Yes	0.48	FU-T-LT22 BAY Cooper Expulsion BAY-O-NET Current Sensing 10A FU-T-LT22 Cooper Current-Limit ELSP-CBUC 40A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T-LT22 Recommended	S1-Recommended	Update	0.48	FU-T-LT22 BAY Cooper Expulsion BAY-O-NET Dual Sensing 15A FU-T-LT22 Cooper Current-Limit ELSP-CBUC 80A	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T-LT23	As Found	Yes	0.48	FU-T-LT23 BAY Cooper Expulsion BAY-O-NET Current Sensing 10A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T-LT23 Recommended	S1-Recommended	Update	0.48	FU-T-LT23 BAY Cooper Expulsion BAY-O-NET Dual Sensing 8A	
T-LT27	As Found	Yes	0.48	FU-T-LT27 BAY Cooper Expulsion BAY-O-NET Current Sensing 10A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T-LT27 Recommended	S1-Recommended	Update	0.48	FU-T-LT27 BAY Cooper Expulsion BAY-O-NET Dual Sensing 8A	
T-LT28	As Found	Yes	0.48	FU-T-LT28 BAY Cooper Expulsion BAY-O-NET Current Sensing 10A	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
T-LT28 Recommended	S1-Recommended	Update	0.48	FU-T-LT28 BAY Cooper Expulsion BAY-O-NET Dual Sensing 8A	
T5111	As Found	Yes	0.48	LVB-B5111 (PNL Y) GE J600 TJK6 Frame = 600A (600AT) Trip = 600 Inst = HI (6000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T5111 Recommended	S1-Recommended	Update	0.48	LVB-B5111 (PNL Y) GE J600 TJK6 Frame = 600A (600AT) Trip = 600	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = LO (1800A)	
T7316B	As Found	Yes	0.208	LVB-B7316B GE J600 THJK4 Frame = 400A (250AT) Trip = 250 Inst = 2500 (2500A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7316B Recommended	S1-Recommended	Update	0.208	LVB-B7316B GE J600 THJK4 Frame = 400A (250AT) Trip = 250 Inst = 1500 (1500A)	
T9203	As Found	Yes	0.208	P-B4-77 Kearney Fuse Links K 25 LVB-B9203 SE1 (MAIN) Cutler Hammer Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = HIGH (6000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.
T9203 Recommended	S1-Recommended	Update	0.208	P-B4-77 Kearney Fuse Links K 10 LVB-B9203 SE1 (MAIN) Cutler Hammer Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = LOW (3000A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T8140	As Found	Yes	0.48	LVB-B8140 Siemens Sentron ND6 Frame = 1200A(900-1200T Trip = 1000 Inst = High (10000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T8140 Recommended	S1-Recommended	Update	0.48	LVB-B8140 Siemens Sentron ND6 Frame = 1200A(900-1200T Trip = 1000 Inst = Low (5000A)	
T11959	As Found	Yes	0.208	LVB-B11959 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T11959 Recommended	S1-Recommended	Update	0.208	LVB-B11959 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Min (900A) ST Delay = Fixed ST Delay I ² t = In Inst = Min (1824A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T8202B	As Found	Yes	0.48	LVB-B8202B (HDP) GE Spectra RMS Sensor = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = Max (4000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (8144A) P-C2-10 Kearney Fuse Links K 80	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.
T8202B Recommended	S1-Recommended	Update	0.48	LVB-B8202B (HDP) GE Spectra RMS Sensor = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = Min (1200A) ST Delay = Fixed ST Delay I ² t = In Inst = Min (2432A) P-C2-10 Kearney Fuse Links K 40	
TR-62	As Found	Yes	0.24	LVB-B-62 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t =	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Out Inst = 14000A	
TR-62 Recommended	S1-Recommended	Update	0.24	LVB-B-62 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 3 (2400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-63	As Found	Yes	0.24	LVB-B-63 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-63 Recommended	S1-Recommended	Update	0.24	LVB-B-63 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 3 (1800A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-64	As Found	Yes	0.24	LVB-B-64 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-64 Recommended	S1-Recommended	Update	0.24	LVB-B-64 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 3 (2400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-66	As Found	Yes	0.24	LVB-B-66 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-66 Recommended	S1-Recommended	Update	0.24	LVB-B-66 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 3 (2400A) ST Delay = Inst ST Delay I ² t = Out	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Out Inst = 14000A	
TR-67	As Found	Yes	0.24	LVB-B-67 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-67 Recommended	S1-Recommended	Update	0.24	LVB-B-67 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 2 (1600A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-69	As Found	Yes	0.24	LVB-B-69 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-69 Recommended	S1-Recommended	Update	0.24	LVB-B-69 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-70	As Found	Yes	0.24	LVB-B-70 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-70 Recommended	S1-Recommended	Update	0.24	LVB-B-70 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-71	As Found	Yes	0.24	LVB-B-71 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-71 Recommended	S1-Recommended	Update	0.24	LVB-B-71 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-73	As Found	Yes	0.24	LVB-B-73 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-73 Recommended	S1-Recommended	Update	0.24	LVB-B-73 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I ² T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-74	As Found	Yes	0.24	LVB-B-74 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-74 Recommended	S1-Recommended	Update	0.24	LVB-B-74 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 3 (2400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-75	As Found	Yes	0.24	LVB-B-75 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I ² T	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				(Fixed) ST Delay I ² t = In Inst = 14000A	
TR-75 Recommended	S1-Recommended	Update	0.24	LVB-B-75 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-76	As Found	Yes	0.24	LVB-B-76 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-76 Recommended	S1-Recommended	Update	0.24	LVB-B-76 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t =	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				In Inst = 14000A	
TR-77	As Found	Yes	0.24	LVB-B-77 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = 12T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-77 Recommended	S1-Recommended	Update	0.24	LVB-B-77 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = 12T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-78	As Found	Yes	0.24	LVB-B-78 (MAIN) Cutler Hammer Series C JD Frame = 250A Trip = 250 Inst = High (2500A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-78 Recommended	S1-Recommended	Update	0.24	LVB-B-78 (MAIN) Cutler Hammer Series C JD Frame = 250A Trip = 250 Inst = Low (1250A)	
TR-80	As Found	Yes	0.24	LVB-B-80 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-80 Recommended	S1-Recommended	Update	0.24	LVB-B-80 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-81	As Found	Yes	0.24	LVB-B-81 Cutler- Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-81 Recommended	S1-Recommended	Update	0.24	LVB-B-81 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	
TR-82	As Found	Yes	0.24	LVB-B-82 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 8 (4800A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-82 Recommended	S1-Recommended	Update	0.24	LVB-B-82 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
TR-83	As Found	Yes	0.24	LVB-B-83 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-83 Recommended	S1-Recommended	Update	0.24	LVB-B-83 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 2 (1600A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
TR-84	As Found	Yes	0.24	LVB-B-84 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 8 (6400A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TR-84 Recommended	S1-Recommended	Update	0.24	LVB-B-84 Cutler-Hammer DT RMS 310 Frame = 800 Plug = 800 Cur Set = 1 (800A) LT Band = Fixed STPU = 2 (1600A) ST Delay = Inst ST Delay I ² t =	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Out Inst = 14000A	
T5013	As Found	Yes	0.48	LVB-B5013 (MSB) Square D Micrologic 6.0A Sensor = 1600 Plug = 1600 Cur Set = 0.8 (1280A) LT Band = 12 STPU = 6 (7680A) ST Delay = 0.1 ST Delay I ² t = Out Override = 57000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T5013 Recommended	S1-Recommended	Update	0.48	LVB-B5013 (MSB) Square D Micrologic 6.0A Sensor = 1600 Plug = 1600 Cur Set = 0.8 (1280A) LT Band = 1 STPU = 5 (6400A) ST Delay = 0.1 ST Delay I ² t = Out Override = 57000A	
T4314	As Found	Yes	0.48	LVB-B4314 (MAIN) Cutler- Hammer DT 520 Family Frame = 800 Plug = 800 Cur Set = 0.95 (760A) LT Band = 24 STPU = 6 (4560A) ST Delay = 0.2 ST Delay I ² t = Out	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = M1 (11200A)	
T4314 Recommended	S1-Recommended	Update	0.48	LVB-B4314 (MAIN) Cutler-Hammer DT 520 Family Frame = 800 Plug = 800 Cur Set = 0.95 (760A) LT Band = 2 STPU = 2.5 (1900A) ST Delay = 0.1 ST Delay I ² t = Out Inst = 4 (3200A)	
TC10	As Found	Yes	0.24	LVB-B-C10 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC10 Recommended	S1-Recommended	Update	0.24	LVB-B-C10 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = 2 (2310A)	
TC11	As Found	Yes	0.24	LVB-B-C11 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC11 Recommended	S1-Recommended	Update	0.24	LVB-B-C11 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
TC5	As Found	Yes	0.24	LVB-B-C5 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = Max (6072A)	
TC5 Recommended	S1-Recommended	Update	0.24	LVB-B-C5 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
TC6	As Found	Yes	0.24	LVB-B-C6 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC6 Recommended	S1-Recommended	Update	0.24	LVB-B-C6 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = 2 (2310A)	
TC7	As Found	Yes	0.24	LVB-B-C7 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC7 Recommended	S1-Recommended	Update	0.24	LVB-B-C7 SE1 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
TC8	As Found	Yes	0.24	LVB-B-C8 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = Max (6072A)	
TC8 Recommended	S1-Recommended	Update	0.24	LVB-B-C8 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
TC9	As Found	Yes	0.24	LVB-B-C9 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC9 Recommended	S1-Recommended	Update	0.24	LVB-B-C9 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = 2 (2310A)	
T95S1-1	As Found	Yes	0.24	LVB-B95S1-1 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T95S1-1 Recommended	S1-Recommended	Update	0.24	LVB-B95S1-1 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
T95S1-3	As Found	Yes	0.24	LVB-B95S1-3 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				ST Delay $I^2t = I_n$ Inst = Max (6072A)	
T95S1-3 Recommended	S1-Recommended	Update	0.24	LVB-B95S1-1 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay $I^2t = I_n$ Inst = 2 (2310A)	
T95S2-2	As Found	Yes	0.24	LVB-B95S2-2 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay $I^2t = I_n$ Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T95S2-2 Recommended	S1-Recommended	Update	0.24	LVB-B95S2-2 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				ST Delay $I^2t = I_n$ Inst = 2 (2310A)	
T95S2-4	As Found	Yes	0.24	LVB-B95S2-4 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay $I^2t = I_n$ Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T95S2-4 Recommended	S1-Recommended	Update	0.24	LVB-B95S2-4 (MAIN) GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay $I^2t = I_n$ Inst = 2 (2310A)	
TB4	As Found	Yes	0.24	LVB-B-B4 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay $I^2t =$	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				In Inst = Max (6072A)	
TB4 Recommended	S1-Recommended	Update	0.24	LVB-B-B4 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
TB8	As Found	Yes	0.24	LVB-B-B8 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TB8 Recommended	S1-Recommended	Update	0.24	LVB-B-B8 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = 2 (2310A)	
TC3	As Found	Yes	0.24	LVB-B-C3 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = Max (3000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (6072A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
TC3 Recommended	S1-Recommended	Update	0.24	LVB-B-C3 GE Spectra RMS Frame = 600 Plug = 600 Cur Set = 1 (600A) LT Band = Fixed STPU = 2 (1080A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (2310A)	
T5020	As Found	Yes	0.24	LVB-B5020 Cutler-Hammer DT 520 Family Frame = 1600 (1600) Plug = 1600 Cur Set = 0.95 (1520A) LT Band = 7 STPU = 6 (9120A) ST Delay = 0.2 ST Delay I ² t = Out	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = M1 (19200A)	
T5020 Recommended	S1-Recommended	Update	0.24	LVB-B5020 Cutler-Hammer DT 520 Family Frame = 1600 (1600) Plug = 1600 Cur Set = 0.8 (1280A) LT Band = 4 STPU = 2.5 (3200A) ST Delay = 0.1 ST Delay I ² t = Out Inst = 4 (6400A)	
T7007B	As Found	Yes	0.48	LVB-B7007B I-T-E OD-6 K-225-2000 Trip = 1000 LTPU = 1 (1000A) Inst = 14.8 (14800A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7007B Recommended	S1-Recommended	Update	0.48	LVB-B7007B I-T-E OD-6 K-225-2000 Trip = 1000 LTPU = 1 (1000A) Inst = 500% (5000A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7008A	As Found	Yes	0.48	P-B2-46 Kearney Fuse Links K 40 LVB-B7008A (MAIN) Challenger RMS 310 Frame = 2000 Plug = 2000 Cur Set = 1 (2000A) LT Band = Fixed STPU = 8 (16000A) ST Delay = Inst ST Delay I ² t = Out Inst = 8 (16000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7008A Recommended	S1-Recommended	Update	0.48	P-B2-46 Kearney Fuse Links K 80 LVB-B7008A (MAIN) Challenger RMS 310 Frame = 2000 Plug = 2000 Cur Set = 1 (2000A) LT Band = Fixed STPU = 3 (6000A) ST Delay = Inst ST Delay I ² t = Out Inst = 5 (10000A)	
T7223	As Found	Yes	0.48	B7223-CH1 Siemens Sentron HMXD6 Frame = 800A(600- 800T) Trip = 800 Inst = High (8000A) B7223-CH2 Siemens Sentron HMXD6 Frame =	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				800A(600-800T) Trip = 700 Inst = High (8000A)	
T7223 Recommended	S1-Recommended	Update	0.48	B7223-CH1 Siemens Sentron HMXD6 Frame = 800A(600-800T) Trip = 800 Inst = Low (4000A) B7223-CH2 Siemens Sentron HMXD6 Frame = 800A(600-800T) Trip = 700 Inst = Low (4000A)	
T5224B	As Found	Yes	0.48	LVB-B5224B (MAIN NO.2) West Seltronic Sensor = 2500A (Fixed) Plug = 2500 Cur Set = 1 (2500A) LT Band = Fixed STPU = 8x (20000A) ST Delay = Fixed ST Delay I ² t = In Inst = 37000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T5224B Recommended	S1-Recommended	Update	0.48	LVB-B5224B (MAIN NO.2) West Seltronic Sensor = 2500A (Fixed) Plug = 2500 Cur Set = 1 (2500A) LT Band = Fixed STPU = 5x (12500A) ST Delay = Fixed ST Delay I ² t = In Inst = 37000A	
T8031	As Found	Yes	0.208	LVB-B8031 Square D Micrologic 5.0A Sensor = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = 1 STPU = 4 (4800A) ST Delay = 0.3 ST Delay I ² t = In Inst = 4 (4800A) Override = 24000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T8031 Recommended	S1-Recommended	Update	0.208	LVB-B8031 Square D Micrologic 5.0A Sensor = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = 1 STPU = 1.5 (1800A) ST Delay = 0.1 ST Delay I ² t = In Inst = 2 (2400A) Override = 24000A	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7104	As Found	Yes	0.48	LVB-B7104 (MDP) Square D Micrologic Std Sensor = 2000 Plug = 2000 Cur Set = 1 (2000A) LT Band = 4.5 STPU = 2.5 (5000A) ST Delay = 0.5 ST Delay I ² t = In Inst = 6 (12000A)	To better Coordinate with upstream equipment, we felt that the instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7104 Recommended	S1-Recommended	Update	0.48	LVB-B7104 (MDP) Square D Micrologic Std Sensor = 2000 Plug = 2000 Cur Set = 1 (2000A) LT Band = 2 STPU = 2.5 (5000A) ST Delay = 0.5 ST Delay I ² t = In Inst = 2.5 (5000A)	
T5209	As Found	Yes	0.208	P-C4-L5-34 Kearney Fuse Links K 80	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.
T5209 Recommended	S1-Recommended	Update	0.208	P-C4-L5-34 Kearney Fuse Links K 10	
T8015	As Found	Yes	0.208	P-C3-15 Kearney Fuse Links K 15	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.
T8015 Recommended	S1-Recommended	Update	0.208	P-C3-15 Kearney Fuse Links K 25	
T9265	As Found	Yes	0.208	P-B4-90 Kearney Fuse Links K 6	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T9265 Recommended	S1-Recommended	Update	0.208	P-B4-90 Kearney Fuse Links K 8	coordinate with the downstream XFMR.
T-FLOOD1	As Found	Yes	0.48	FSW-P-B3-L2-6 Kearney Fuse Links K 8	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
T-FLOOD1 Recommended	S1-Recommended	Update	0.48	FSW-P-B3-L2-6 Kearney Fuse Links K 12	
TP-B3-L2-7	As Found	Yes	0.24	P-B3-L2-7 Kearney Fuse Links K 6	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
TP-B3-L2-7 Recommended	S1-Recommended	Update	0.24	P-B3-L2-7 Kearney Fuse Links K 2	
T9219	As Found	Yes	0.24	FSW-P-B4-62 Kearney Fuse Links K 20 LVB-B9219 (MAIN) Cutler- Hammer DT RMS 310 Frame = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = Fixed STPU = 8 (9600A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with transformer protection.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T9219 Recommended	S1-Recommended	Update	0.24	FSW-P-B4-62 Kearney Fuse Links K 100 LVB-B9219 (MAIN) Cutler- Hammer DT RMS 310 Frame = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = Fixed STPU = 4 (4800A) ST Delay = Inst ST Delay I ² t = Out Inst = 14000A	
T5112	As Found	Yes	0.48	P-C3-19A Kearney Fuse Links K 25 LVB-B5112 (MSB) SE1 GE Power+ Sensor = 2000 Plug = 2000 Cur Set = 1 (2000A) LT Band = 2 STPU = 7 (14000A) ST Delay = Int ST Delay I ² t = In Inst = 10 (20000A) LVB-B5112 (CHILLER1) GE microEntelliG Sensor = 800 Plug = 700 Cur Set = 0.5 (350A) LT Curve = Thermal (I ² T) LT Band = Min CB STPU = 1.5 (525A) ST Delay = 1 ST Delay I ² t =	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with motor protection.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Out Inst = 2 (1600A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T5112 Recommended	S1-Recommended	Update	0.48	P-C3-19A Kearney Fuse Links K 65 LVB-B5112 (MSB) SE1 GE Power+ Sensor = 2000 Plug = 2000 Cur Set = 0.9 (1800A) LT Band = 2 STPU = 2 (3600A) ST Delay = Int ST Delay I²t = In Inst = 5 (10000A) LVB-B5112 (CHILLER1) GE microEntelliG Sensor = 800 Plug = 700 Cur Set = 0.9 (630A) LT Curve = Thermal (I²T) LT Band = Max CB STPU = 1.5 (945A) ST Delay = 1 ST Delay I²t = Max Inst = 2 (1600A)	
T5142	As Found	Yes	0.48	FDSC-B5142 SE1 BUSS (Std) FRS (K5) 300A~	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "FSDC (Fuse Disconnect)" should be brought down in order to better coordinate with the Upstream XFMR.
T5142 Recommended	S1-Recommended	Update	0.48	FDSC-B5142 SE1 BUSS (Std) FRS-R(RK5) 300A~	
T6115	As Found	Yes	0.208	LVB-B6115 Challenger Series C CJ Frame = 250A Trip = 100	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				Inst = High (1000A)	
T6115 Recommended	S1-Recommended	Update	0.208	LVB-B6115 Challenger Series C CJ Frame = 250A Trip = 100 Inst = Low (500A)	
T6119	As Found	Yes	0.208	LVB-B6119 Challenger Series C CJ Frame = 250A Trip = 150 Inst = High (1500A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T6119 Recommended	S1-Recommended	Update	0.208	LVB-B6119 Challenger Series C CJ Frame = 250A Trip = 150 Inst = Low (750A)	
T6122A	As Found	Yes	0.208	LVB-B6122A GE Spectra RMS Frame = 250 Plug = 250 Cur Set = 1 (250A) LT Band = Fixed STPU = Max (1250A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (2500A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T6122A Recommended	S1-Recommended	Update	0.208	LVB-B6122A GE Spectra RMS Frame = 250 Plug = 250 Cur Set = 1 (250A) LT Band = Fixed STPU = Min (375A) ST Delay = Fixed ST Delay I ² t =	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
				In Inst = Min (750A)	
T6122B	As Found	Yes	0.208	LVB-B6122B GE Spectra RMS Frame = 400 Plug = 400 Cur Set = 1 (400A) LT Band = Fixed STPU = Max (2000A) ST Delay = Fixed ST Delay I ² t = In Inst = Max (4048A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T6122B Recommended	S1-Recommended	Update	0.208	LVB-B6122B GE Spectra RMS Frame = 400 Plug = 400 Cur Set = 1 (400A) LT Band = Fixed STPU = 2 (760A) ST Delay = Fixed ST Delay I ² t = In Inst = 2 (1540A)	
T6123	As Found	Yes	0.208	LVB-B6123 Challenger Series C CJ Frame = 250A Trip = 200 Inst = High (2000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T6123 Recommended	S1-Recommended	Update	0.208	LVB-B6123 Challenger Series C CJ Frame = 250A Trip = 200 Inst = Low (1000A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7403	As Found	Yes	0.208	LVB-B7403 Cutler Hammer Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = HIGH (6000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7403 Recommended	S1-Recommended	Update	0.208	LVB-B7403 Cutler Hammer Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = LOW (3000A)	
T7407	As Found	Yes	0.208	B7407 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = HIGH (4000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7407 Recommended	S1-Recommended	Update	0.208	B7407 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = LOW (2000A)	
T7409	As Found	Yes	0.12	LVB-B7409 (D-07) SE1 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = HIGH (4000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7409 Recommended	S1-Recommended	Update	0.12	LVB-B7409 (D-07) SE1 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = LOW (2000A)	
T7421	As Found	Yes	0.208	LVB-B7421 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = HIGH (4000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T7421 Recommended	S1-Recommended	Update	0.208	LVB-B7421 Cutler Hammer Series C KD Frame = 400A(100-400AT) Trip = 400 Inst = LOW (2000A)	
T8215	As Found	Yes	0.48	LVB-B8215 West Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = HIGH (6000A)	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T8215 Recommended	S1-Recommended	Update	0.48	LVB-B8215 West Series C LD Frame = 600A(300-600AT) Trip = 600 Inst = LOW (3000A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T5105	As Found	Yes	0.48	LVB-B5105 Cutler-Hammer DT RMS 310 Frame = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = Fixed STPU = 6 (7200A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
T5105 Recommended	S1-Recommended	Update	0.48	LVB-B5105 Cutler-Hammer DT RMS 310 Frame = 1200 Plug = 1200 Cur Set = 1 (1200A) LT Band = Fixed STPU = 3 (3600A) ST Delay = I2T (Fixed) ST Delay I ² t = In Inst = 14000A	
T9243	As Found	Yes	0.48	P-B4-68 Kearney Fuse Links K3	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
T9243 Recommended	S1-Recommended	Update	0.48	P-B4-68 Kearney Fuse Links K6	
T7000A	As Found	Yes	0.48	LVB-B7000A GE MVT RMS-9 Sensor = 1600 Plug = 1200 Cur Set = 0.8 (960A) LT Band = 3 Inst = 10 (12000A)	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7000A Recommended	S1-Recommended	Update	0.48	LVB-B7000A GE MVT RMS-9 Sensor = 1600 Plug = 1200 Cur Set = 0.8 (960A) LT Band = 3 STPU = 5 (4800A) ST Delay = Min ST Delay I^2t = In Inst = 5 (6000A)	
T7000B	As Found	Yes	0.48	LVB-B7000B GE MVT RMS-9 Sensor = 1600 Plug = 1200 Cur Set = 0.8 (960A) LT Band = 3 Inst = 10 (12000A)	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.
T7000B Recommended	S1-Recommended	Update	0.48	LVB-B7000B GE MVT RMS-9 Sensor = 1600 Plug = 1200 Cur Set = 0.8 (960A) LT Band = 3 STPU = 5 (4800A) ST Delay = Min ST Delay I^2t = In Inst = 5 (6000A)	
T7234	As Found	Yes	0.208	LVB-B7234 Siemens Sentron ND6 Frame = 1200A(800T) Trip = 800 Inst = High (8000A)	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.
T7234 Recommended	S1-Recommended	Update	0.208	LVB-B7234 Siemens Sentron ND6 Frame = 1200A(800T) Trip = 800 Inst = 6 (6850A)	

TCC CURVE NAME	As Found / S#:Recommended	Adjustments Recommended (YES / NO)	BASE Voltage (kV)	Setting Changes	Summary of Curve / Recommendation
T7302	As Found	Yes	0.208	FDSC-B7302 (SERVICE DISCONNECT) BUSS (Std) KRP-C_SP 1600A	The distribution system has arc flash issues at this location. Fuse Type was adjusted to lower arc flash ratings in this location.
T7302 Recommended	S1-Recommended	Update	0.208	FDSC-B7302 (SERVICE DISCONNECT) BUSS High Speed FWH-A 1600A	

Note: Transformer BAY-O-NET Fuse size and type were assumed/determined based on manufacture recommendations. Prior to addressing BAY-O-NET Fuse recommendations, Further investigation regarding the exact type of BAY-O-NET Fuse inside the Transformers should be performed.

9.3 Recommended Equipment Setting Adjustments

The following violations/issues have been identified at the following locations. A recommended route of mitigation is provided in Table 9-2:

Table 9-2
Other Recommendations Not Related to Coordination

TCC Curve / Equipment Name	BASE Voltage (kV)	Possible Equipment Violation	Recommendation
T9018	0.24	C-B9018 SE2 (1 - 4 AWG Cu.) LVB-B9018 SE2	To better meet NEC Standard 450.3 and 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment and cable needed at each service entrance.
T4127	0.48	C-B4127 SE3 1 - 6 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B4127 SE3 should be sized up to better fit the fused service entrance FDSC-B4127 SE3.
T4202	0.208	C-B4202 (PANEL D) SE2 1 - 1/0 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B4202 (PANEL D) SE2 should be sized up to better fit the fused service entrance FDSC-B4202 (PANEL D) SE2.
T9045	0.208	C-B9045 SE1 1 - 1/0 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B9045 SE1 should be sized up to better fit the fused service entrance LV-B9045 SE1.
T8211	0.208	C-B8211 (SERVICE DISC.) 2 - 300 kcmil AL	To better meet NEC Standard 310.16, we felt that the cable C-B8211 (SERVICE DISC.) should be sized up to better fit the fused service entrance LV-B8211 (SERVICE DISC.).

TCC Curve / Equipment Name	BASE Voltage (kV)	Possible Equipment Violation	Recommendation
T1-24	0.24	SE1 - SE7	To better meet NEC Standard 450.3, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment and cable needed at each service entrance.
T-BOMBPAD	0.208	C- B-BOMBPAD 1 - 2 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B-BOMBPAD should be sized up to better fit the fused service entrance B-BOMBPAD.
T9329	0.48	C-B9329 SE1 1 - 6 AWG CU C-B9329 SE3 1 - 300 kcmil CU	To better meet NEC Standard 310.16, we felt that the cables C-B9329 SE1 and C-B9329 SE3 should be sized up to better fit the respective service entrance.
T6222	0.208	C-B6222 1 - 300 kcmil CU LVB-B6222	To better meet NEC Standard 450.3 and 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment and cable needed at each service entrance.
T7007B	0.48	C-B7007B 2 - 500kcmil CU	To better meet NEC Standard 310.16, we felt that the cable C-B7007B should be sized up to better fit respective service entrance.
T7008A	0.48	C-B7008A (MAIN) 2 - 500kcmil CU	To better meet NEC Standard 310.16, we felt that the cable C-B7008A (MAIN) should be sized up to better fit respective service entrance.
T7104	0.48	C - B7104 2 - 500kcmil CU	To better meet NEC Standard 310.16, we felt that the cable C-B7104 should be sized up to better fit respective service entrance.
T-LT12	0.24	C - B-LT12 1 - 2/0 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B-LT12 should be sized up to better fit respective service entrance.
T6030A	0.48	Junction Box / Transformer	While there is no violation at this location, it is recommended to add primary protection to the Junction Box JB2-27, T6030A, or T6030B. This will allow for faults at either of those locations to be cleared locally.
T6030B	0.48	Junction Box / Transformer	While there is no violation at this location, it is recommended to add primary protection to the Junction Box JB2-27, T6030A, or T6030B. This will allow for faults at either of those locations to be cleared locally.
T4300	0.48	C - B4300 SE3 1 - 2 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B-B4300 should be sized up to better fit respective service entrance.
T5138	0.48	C-B5138 (LIGHT POLE) SE3 1 - 12 AWG CU	To better meet NEC Standard 310.16, we felt that the cable C-B-B5138 (LIGHT POLE) SE3 should be sized up to better fit respective service entrance.
T8013	0.208	C-B8013 SE1 1 - 1/0 AWG CU C-B8013 SE4 1 - 4/0 AWG CU	To better meet NEC Standard 310.16, we felt that the cables C-B8013 SE1 and C-B8013 SE4 should be sized up to better fit respective service entrance.

TCC Curve / Equipment Name	BASE Voltage (kV)	Possible Equipment Violation	Recommendation
T9121A	0.12	C-B9121A SE1 1 - 12 AWG CU	To better meet NEC Standard 310.16, we felt that the cables C-B9121A SE2 should be sized up to better fit respective service entrance.
B5110A SE1 OUT	0.48	B5110A SE1 OUT	The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
B5224B (MAIN NO.2) OUT	0.48	B5224B (MAIN NO.2) OUT	The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
B6030B OUT	0.48	B6030B OUT	The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
B7008C (SWBD MA) OUT	0.208	B7008C (SWBD MA) OUT	The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
TR-61	0.24	C-B-61 2 - 350 kcmil CU LVB-B-61 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-62	0.24	C-B-62 2 - 350 kcmil CU LVB-B-62 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-64	0.24	C-B-64 2 - 350 kcmil CU LVB-B-64 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-66	0.24	C-B-66 2 - 350 kcmil CU LVB-B-66 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.

TCC Curve / Equipment Name	BASE Voltage (kV)	Possible Equipment Violation	Recommendation
TR-67	0.24	C-B-67 2 - 350 kcmil CU LVB-B-67 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-74	0.24	C-B-74 2 - 350 kcmil CU LVB-B-74 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-83	0.24	C-B-83 2 - 350 kcmil CU LVB-B-83 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
TR-84	0.24	C-B-84 2 - 350 kcmil CU LVB-B-84 800A	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
T6222	0.24	C-B6222 1-300 kcmil CU LVB-B6222 600A	To better meet NEC Standard 450.3 and 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment and cable needed at each service entrance.

10

ADDITIONAL EVALUATIONS

Section 10 provides additional evaluations performed as part of this power system study. The evaluations address:

- Harmonic distortion.
- Distribution Reliability

10.1 Harmonic Distortion

10.1.1 *Purpose of Harmonic Distortion Evaluation*

The ideal voltage or current is provided as a 60 Hz sinusoidal waveform, often referred to as the fundamental frequency. The term *harmonics* refers to other frequency signals that are superimposed onto the fundamental frequency. Figure 10-1 shows the waveform of the second through fifth harmonics superimposed onto the fundamental frequency. Figure 10-2 shows an example of the resultant waveform when the fundamental frequency is combined with a large third harmonic.

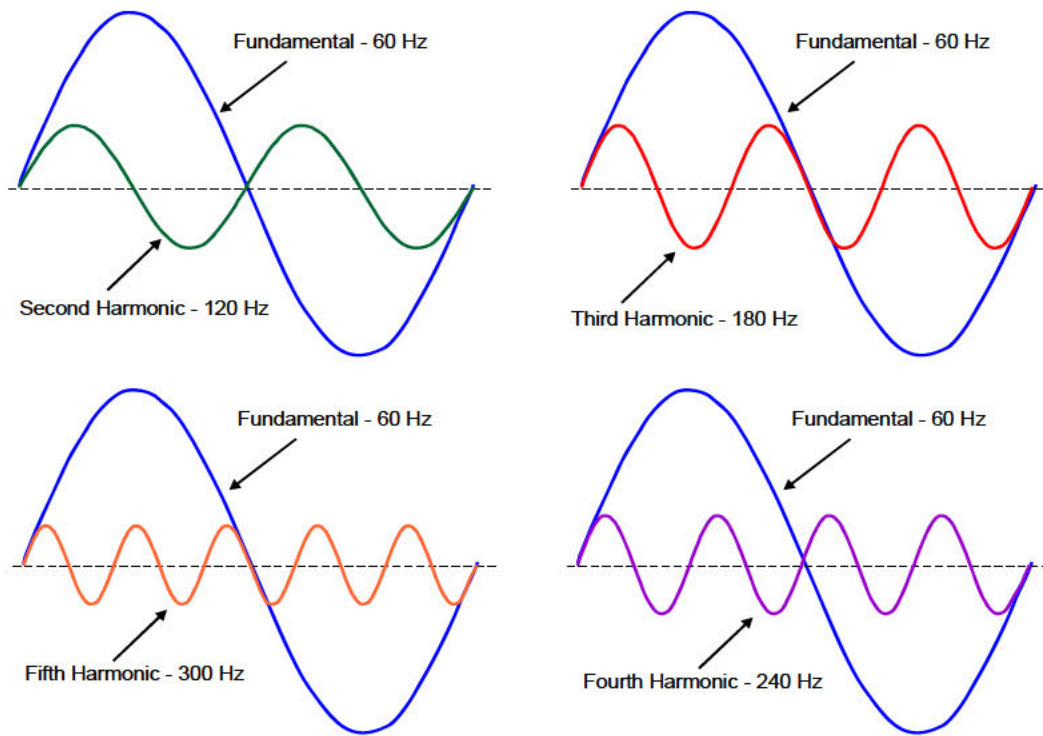


Figure 10-1
Harmonics of the Fundamental Frequency

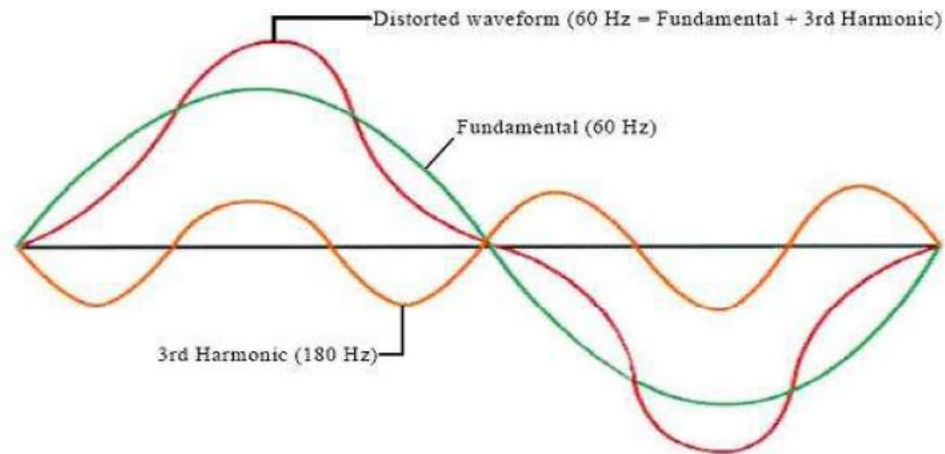


Figure 10-2
Distorted 60 Hz Waveform (1st and 3rd Harmonics)

Certain types of equipment can introduce harmonics into the electrical power distribution system. The cumulative effect can eventually cause problems, including transformer overheating, excessive neutral conductor current, equipment malfunction, and inaccurate protective relay performance. The objective of the harmonics evaluation is to determine if potentially harmful levels of harmonic distortion exist in the system.

Power electronics devices are the most significant source of harmonic distortion. Harmonic distortion problems are usually amplified when the facility has nonlinear loads and has power factor correction capacitors installed; resonance conditions can magnify the harmonic distortion. Nonlinear loads tend to draw current in a manner that causes distorted current waveforms which can be represented as the summation of the fundamental frequency and additional harmonic frequencies. Figure 10-3 shows the resultant waveform for a load with significant third and fifth harmonics. Notice that the addition of harmonics causes the desired sinusoidal wave to assume more of a square wave appearance.

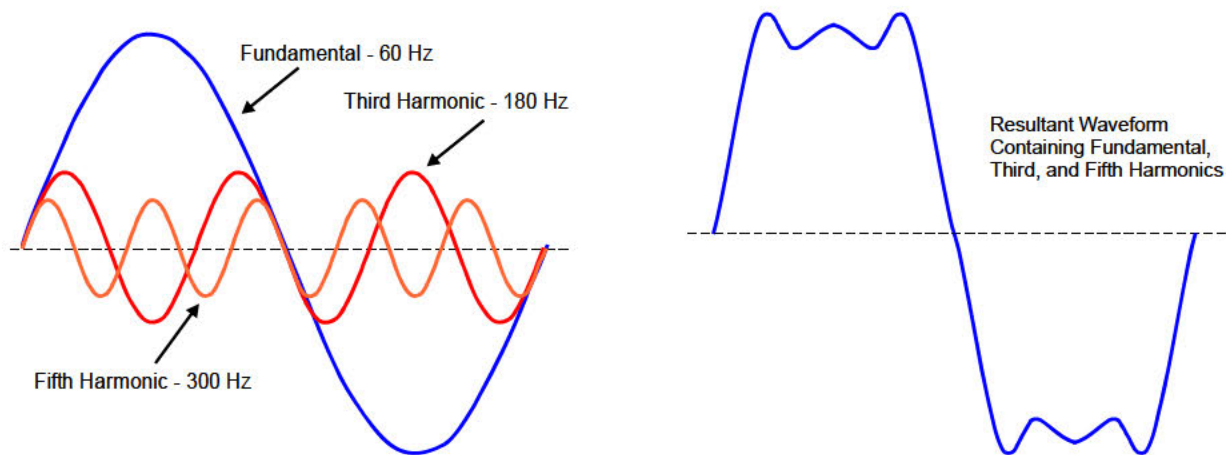


Figure 10-3
Effect of Harmonics on the Sinusoidal Waveform

10.1.2 Harmonic Measurements

Unlike the other analyses conducted in this engineering study, the harmonics evaluation is based on measured rather than analytical values. Spot measurements were taken throughout the system as part of the field surveys and were generally acquired at the generator and/or service entrance where safe measurements were possible.

Snapshot harmonic distortion levels were recorded with a Dranetz power quality analyzer. The measurement is specified as a percent THD, which represents the percentage of *Total Harmonic Distortion* in the power signal at the point of measurement. THD was measured for both the voltage and current waveforms.

10.1.3 Evaluation Criteria

IEEE 519, *IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems*, provides recommended distortion limits for a low voltage system. Figure 10-4 and Figure 10-5 show tables from IEEE 519 (IEEE Table 11-1 and IEEE Table 10-3). General purpose applications are allowed up to 5 percent voltage THD. Hospitals are classified as special applications and have the most stringent requirements with a voltage (THD) limit of 3 percent at the Point of Common Coupling (PCC). Current (ampere) THD requirements are not as stringent as the voltage THD limits and 20 percent current THD is often acceptable at the PCC.

Table 11-1—Voltage Distortion Limits

Bus Voltage at PCC	Individual Voltage Distortion (%)	Total Voltage Distortion THD (%)
69 kV and below	3.0	5.0
69.001 kV through 161 kV	1.5	2.5
161.001 kV and above	1.0	1.5

NOTE — High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal that will attenuate by the time it is tapped for a user.

Figure 10-4
Voltage Distortion Limits Specified in IEEE 519

Table 10-3—Current Distortion Limits for General Distribution Systems (120 V Through 69 000 V)

Maximum Harmonic Current Distortion in Percent of I_L						
Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_L	<11	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h$	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0
Even harmonics are limited to 25% of the odd harmonic limits above.						
Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.						
* All power generation equipment is limited to these values of current distortion, regardless of actual I_{sc}/I_L .						
where I_{sc} = maximum short-circuit current at PCC. I_L = maximum demand load current (fundamental frequency component) at PCC.						

Figure 10-5
Current Distortion Limits Specified in IEEE 519

10.1.4 Results

Voltage harmonic distortion was less than 3% percent within the system. There were no locations where Voltage Total Harmonic Distortion was greater than 5%.

Current harmonic distortion reached 100% in seven locations within the system. Current harmonic distortion varies considerably.

Harmonic distortion data is collected via instantaneous spot measurements at the secondary transformer level. It is expected that harmonic distortion levels will fluctuate with various loading equipment and loading type connected to the system. As such, without further study consisting of constant metering over a set period, TWN provides harmonic distortion results for informational purposes only.

Table 10-1
Base Case - ITHD > 20%

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
C-B9045 SE2	0.208	0.9	0.9	100.00
BWY-1	12.47	0.1	0.1	100.00
C-EM274	12.47	0.1	0.1	100.00
C-JB2-030 - T7101	12.47	0.1	0.1	100.00
C-T6113 - T6115	12.47	0.1	0.1	100.00
T6115	12.47	0.1	0.1	100.00
T7101	12.47	0.1	0.1	100.00
T6122A	12.47	0.3	0.4	75.00
BWY-B6122A	0.48	6.6	9.2	71.74
L-B6122A	0.48	6.6	9.2	71.74
C-B6115	0.208	5.7	8	71.25
L-B6115	0.208	5.7	8	71.25
C-B5003B	0.48	6.3	9.3	67.74
L-B5003B	0.48	6.3	9.3	67.74
C-T7101 - B7101	0.208	4.1	6.6	62.12
L-B7101	0.208	4.1	6.6	62.12
C-B9097	0.208	15.7	27.3	57.51
L-B9097	0.208	15.7	27.3	57.51
C-B-T9109	0.208	2.4	4.7	51.06
L-T9109 SE1	0.208	2.4	4.7	51.06
T7407	12.47	0.4	0.8	50.00
C-P-B3-L2-3 - SC-9096	12.47	0.2	0.4	50.00
C-SC-9096 - T9097	12.47	0.2	0.4	50.00
C-T5003A - T5003B	12.47	0.2	0.4	50.00
T5003B	12.47	0.2	0.4	50.00
T9097	12.47	0.2	0.4	50.00
C-T7316A - T7316B	12.47	0.1	0.2	50.00
C-T8080A	12.47	0.1	0.2	50.00
T6123	12.47	0.1	0.2	50.00
T7316B	12.47	0.1	0.2	50.00
T8080A	12.47	0.1	0.2	50.00
C-B6141 SE1 (MLO)	0.208	2.6	5.5	47.27
L-B6141 SE1 (MLO)	0.208	2.6	5.5	47.27
C-B5202 (DP)	0.208	13.9	30.1	46.18
L-B5202 (DP)	0.208	13.9	30.1	46.18

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
C-T7407 - T7405	12.47	0.4	0.9	44.44
C-T7405 - T7421	12.47	0.6	1.4	42.86
C-P-C3-21 - T5114	12.47	0.2	0.5	40.00
T5114	12.47	0.2	0.5	40.00
T7405	12.47	0.2	0.5	40.00
C-B6123	0.208	4	10.3	38.83
L-B6123	0.208	4	10.3	38.83
C-B7405 SE2	0.208	5.9	15.2	38.82
L-B7405 SE2	0.208	5.9	15.2	38.82
C-B7405B SE1	0.208	5.6	14.5	38.62
L-B7405 SE1	0.208	5.6	14.5	38.62
C-B5004A (MAIN DISC)	0.48	12.7	32.9	38.60
L-B5004A (MAIN DISC)	0.48	12.7	32.9	38.60
C-P-C4-43 - T5004A	12.47	0.5	1.3	38.46
T5004A	12.47	0.5	1.3	38.46
C-P-C4-42 - T5003A	12.47	0.3	0.8	37.50
T8006	12.47	0.3	0.8	37.50
C-JC2-240 - T7402	12.47	0.8	2.2	36.36
C-T7403 - JC2-240	12.47	0.8	2.2	36.36
T9112A	12.47	0.4	1.1	36.36
C-B9112A	0.48	10.2	28.3	36.04
L-B9112A	0.48	10.2	28.3	36.04
C-T7421 - T7403	12.47	0.7	2	35.00
C-T7217 - B7217	0.208	2.6	7.5	34.67
L-B7217	0.208	2.6	7.5	34.67
C-T9220 - B9220	0.208	1.3	3.8	34.21
L-B9220 SE1	0.208	1.3	3.8	34.21
C-B8032	0.208	8.6	25.3	33.99
L-B8032	0.208	8.6	25.3	33.99
C-B7407 SE1	0.208	15.5	46.4	33.41
L-B7407 SE1	0.208	15.5	46.4	33.41
BWY-65	12.47	0.2	0.6	33.33
C-P-C4-L5-3 - T8040B	12.47	0.2	0.6	33.33
T7007A	12.47	0.2	0.6	33.33
T8040B	12.47	0.2	0.6	33.33
X-279	12.47	0.2	0.6	33.33
C-P-B2-66 - T8130A	12.47	0.1	0.3	33.33

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
C-P-C4-L9-4 - T5108	12.47	0.1	0.3	33.33
T6122B	12.47	0.1	0.3	33.33
T8130A	12.47	0.1	0.3	33.33
X-41	12.47	0.1	0.3	33.33
X-44	12.47	0.1	0.3	33.33
C-B7409 (D-07) SE1	0.208	1.5	4.5	33.33
L-7409 (D-07) SE1	0.208	1.5	4.5	33.33
C-T9220 - B9220-RV	0.208	1.4	4.3	32.56
L-B9220 SE2	0.208	1.4	4.3	32.56
C-B7316B	0.208	4.7	14.7	31.97
L-B7136B	0.208	4.7	14.7	31.97
C-B8080A	0.208	3	9.6	31.25
L-B8080A	0.208	3	9.6	31.25
C-B8006 SE2	0.208	8	26.2	30.53
L-B8006 SE2	0.208	8	26.2	30.53
C-B7007A SE1	0.208	8	26.3	30.42
L-B7007A SE1	0.208	8	26.3	30.42
C-B8006 (MLO) SE1	0.208	7	23.1	30.30
L-B8006 (MLO)	0.208	7	23.1	30.30
C-B7007A SE2	0.208	3.8	12.6	30.16
L-B7007A SE2	0.208	3.8	12.6	30.16
C-JB2-280 - JB2-290	12.47	0.5	1.7	29.41
C-JB2-290 - JB2-300	12.47	0.5	1.7	29.41
C-JB2-300 - T6030D	12.47	0.5	1.7	29.41
C-P-C4-L8-2 - T8031	12.47	0.5	1.7	29.41
T6030D	12.47	0.5	1.7	29.41
T8031	12.47	0.5	1.7	29.41
X-179	12.47	0.5	1.7	29.41
C-B8031	0.208	30.3	104.1	29.11
L-B8031	0.208	30.3	104.1	29.11
C-JC2-020 - T7106A	12.47	0.2	0.7	28.57
C-T7106B - JC2-020	12.47	0.2	0.7	28.57
T7106A	12.47	0.2	0.7	28.57
X-261	12.47	0.2	0.7	28.57
X-346	12.47	0.2	0.7	28.57
C-B6030D	0.208	28.5	102.3	27.86
L-B6030D (MS)	0.208	28.5	102.3	27.86

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
L-B5212 (MCC RIGHT)	0.48	2.6	9.4	27.66
C-B5115 (PNL A)	0.208	2.1	7.9	26.58
C-JB-B5115	0.208	2.1	7.9	26.58
L-B5115 (PNL A) SE1	0.208	2.1	7.9	26.58
C-B4101 (SW 1 - MAIN DISC)	0.48	2.7	10.2	26.47
L-B4101 (SW 1 - MAIN DISC)	0.48	2.7	10.2	26.47
C-JB2-270 - JB2-280	12.47	0.5	1.9	26.32
C-JB2-280 - T6030C	12.47	0.5	1.9	26.32
C-B8040B SE1B	0.208	2.7	10.3	26.21
C-B8040B SE3	0.208	2.7	10.3	26.21
L-B8040B SE1B	0.208	2.7	10.3	26.21
L-B8040B SE3	0.208	2.7	10.3	26.21
C-B7004B	0.208	1.7	6.5	26.15
L-B7004B	0.208	1.7	6.5	26.15
B7106A	0.208	11.1	42.7	26.00
C-B7106A (MLO)	0.208	11.1	42.7	26.00
C-B8040B SE1A	0.208	4.1	15.8	25.95
L-B8040B SE1A	0.208	4.1	15.8	25.95
C-B8131 (PANEL A) SE1	0.48	2.9	11.3	25.66
L-B8131 (PANEL A) SE1	0.48	2.9	11.3	25.66
C-P-C2-L1-23 - JC2-220	12.47	1.2	4.7	25.53
C-T7402 - JC2-220	12.47	1.2	4.7	25.53
X-145	12.47	1.2	4.7	25.53
X-161	12.47	1.2	4.7	25.53
C-P-B4-25 - EM-20	12.47	0.8	3.2	25.00
C-P-B1-L3-13 - T9001	12.47	0.3	1.2	25.00
T9001	12.47	0.3	1.2	25.00
C-T5105 - T5108B	12.47	0.2	0.8	25.00
T5108B	12.47	0.2	0.8	25.00
C-JC2-100 - T7215	12.47	0.1	0.4	25.00
C-P-B1-L3-24 - T4101	12.47	0.1	0.4	25.00
C-P-B1-L5-5 - T4111	12.47	0.1	0.4	25.00
C-P-B2-8 - T9304	12.47	0.1	0.4	25.00
C-P-C4-36 - T8030	12.47	0.1	0.4	25.00
C-P-C4-L10-1 - T8032	12.47	0.1	0.4	25.00
T4101	12.47	0.1	0.4	25.00

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
T4202	12.47	0.1	0.4	25.00
T7215	12.47	0.1	0.4	25.00
T8030	12.47	0.1	0.4	25.00
T8032	12.47	0.1	0.4	25.00
T9304	12.47	0.1	0.4	25.00
X-95	12.47	0.1	0.4	25.00
X-184	12.47	0.1	0.4	25.00
C-B7403	0.208	2.8	11.3	24.78
L-B7403	0.208	2.8	11.3	24.78
C-B5201 (MLO) SE2	0.208	0.5	2.1	23.81
C-B8131 SE2	0.48	0.5	2.1	23.81
L-B5201 (MLO) SE2	0.208	0.5	2.1	23.81
L-B8131 SE2	0.48	0.5	2.1	23.81
C-T8130A - B8130A	0.48	1.7	7.2	23.61
L-B8130A	0.48	1.7	7.2	23.61
C-B7216	0.208	1.2	5.1	23.53
L-B7216	0.208	1.2	5.1	23.53
C-B8202A (LDP)	0.208	7	30.1	23.26
L-B8202A (LDP)	0.208	7	30.1	23.26
C-B5111 (PNL Y)	0.48	11.7	50.4	23.21
L-B5111 (PNL Y)	0.48	11.7	50.4	23.21
C-B5270 SE1	0.208	0.3	1.3	23.08
L-B5270 SE1	0.208	0.3	1.3	23.08
C-EM-20 - JB4-010	12.47	0.5	2.2	22.73
C-P-C3-9 - T8140	12.47	0.4	1.8	22.22
T8140	12.47	0.4	1.8	22.22
C-P-C4-L5-10 - T5204B	12.47	0.2	0.9	22.22
T5204B	12.47	0.2	0.9	22.22
T7106B	12.47	0.2	0.9	22.22
C-B9110 SE1 (P2-P)_A	0.48	1.6	7.3	21.92
L-B9110 SE3	0.48	1.6	7.3	21.92
C-B9001	0.208	16	73	21.92
L-B9001	0.208	16	73	21.92
C-B7004D (BKR-A) SE2	0.48	0.5	2.3	21.74
C-JB4-010 - T9112A	12.47	0.5	2.3	21.74
L-B7004D (BKR-A) SE2	0.48	0.5	2.3	21.74
C-B11913	0.208	1.3	6	21.67

ITHD Branches	Base KV	ITHD(Amps)	IRSS(Amps)	ITHD%
L-B11913	0.208	1.3	6	21.67
C-B9110 SE1 (P2-P)	0.48	2.2	10.2	21.57
C-B9110 SE2 (P2-LP)	0.48	2.2	10.2	21.57
L-B9110 (P2-P)	0.48	2.2	10.2	21.57
L-B9110 SE2 (P2-P)	0.48	2.2	10.2	21.57
C-T8140 - B8140	0.48	10.3	47.8	21.55
L-B8140	0.48	10.3	47.8	21.55
T6138B	12.47	0.3	1.4	21.43
X-100	12.47	0.3	1.4	21.43
X-101	12.47	0.3	1.4	21.43
C-B8008	0.208	19.7	92	21.41
L-B8008	0.208	19.7	92	21.41
C-B6136B SE2	0.48	0.7	3.3	21.21
L-B6136B SE2	0.48	0.7	3.3	21.21
C-EM-7 - T5111	12.47	0.4	1.9	21.05
T5111	12.47	0.4	1.9	21.05
C-B5108 SE1	0.48	4.7	22.8	20.61
L-B5108B SE1	0.48	4.7	22.8	20.61
C-B5003A SE2	0.208	2.1	10.2	20.59
C-B7233 SE1B	0.208	2.1	10.2	20.59
L-B5003A SE1A_A	0.208	2.1	10.2	20.59
L-B7233 SE1B	0.208	2.1	10.2	20.59
BWY-B6122B	0.208	3.8	18.5	20.54
L-B6122B	0.208	3.8	18.5	20.54
C-B5003A SE1A	0.208	3.3	16.1	20.50
L-B5003A SE1A	0.208	3.3	16.1	20.50
C-B7004A (PNL #A)	0.208	8.6	42.1	20.43
L-B7004A (PNL #A)	0.208	8.6	42.1	20.43
C-B7233 SE1A	0.208	12.7	62.5	20.32
L-B7233 (MAIN) SE1A	0.208	10.6	52.3	20.27
C-B8020	0.208	1.9	9.4	20.21
L-B8020	0.208	1.9	9.4	20.21
C-B7233 SE2	0.208	7.2	35.7	20.17
C-JB-B7233 SE2	0.208	7.2	35.7	20.17
L-B7233 SE2	0.208	7.2	35.7	20.17

Note: The percentages discussed in section 10.1.4 and the values shown in Table 10-1 reflect the Harmonics Summation Summary Report produced by EasyPower based on the power flow

measurements. The values reported in Appendix R and Table 4-1 reflect the field measured instantaneous values during data collection.

10.2 Distribution Reliability

10.2.1 Distribution Reliability Evaluation

IEEE 493 contains recommended design practices for improving the reliability of industrial and commercial power systems.

IEEE 493, annex Q, provides typical failure and repair rates for major electrical components. Where values are unavailable via Annex Q, assumptions based on similar equipment were adopted.

The high contributors ($> 1.0\%$) to load service failures are shown in Table 10-2.

Table 10-2
Distribution Reliability Summary (Major Contributors)

Equipment ID	Failure Contribution (%)	Failure Rate (/Y)	Unavailability (h/Y)	Repair (Hours)
MVB-FDR BKR-1	2.524	0.024	0.348	14.8

The failure rate and repair times are taken directly from IEEE 493.

Distribution reliability evaluation detail is provided in Volume 2 Appendix O for the primary distribution system.

10.3 Oil Sampling (Transformer)

10.3.1 Performance Work Statement (PWS)

For each transformer coordinated with the BCE (Base Civil Engineering) during preliminary data gathering, TEAMWORKnet Inc (TWN) has coordinated with the Base BCE and Electrical Shop to determine which substation transformers that would most benefit from oil sampling. For those transformers selected by the BCE and Electrical shop, TWN was to perform oil sampling and testing in accordance with IEEE C57. 106 as well as all applicable ASTM criteria, as referenced in IEEE C57.106. If any deficiencies are identified during the transformer oil sampling and testing, Contractor would provide recommendations for corrective actions.

10.3.2 Purpose of Oil Sampling

The main function of the oil within a transformer is to insulate and cool the transformer. The oil, therefore, must have a high dielectric strength, thermal conductivity, chemical stability, and the capacity to hold these properties at high temperatures for extended periods of time (high load condition, environmental concerns). Transformer oil analysis provides an indication of the internal

condition of a transformer. Transformer oil ages over time due to loading, contamination (water, gases, metal particulates). As the transformer oil deteriorates, its capacity to provide necessary dielectric and cooling properties diminish. Periodic oil sampling / analysis is recognized to be a cost-effective method to determine transformer health. Detailed diagnostic tests offer insights into thermal damage and/or abnormal electrical activity. These tests also provide aging information and a glimpse into the condition of the transformer and primary/secondary insulation. Over time the transformer oil is exposed to mechanical, and electrical stress (inrush, tap changer movement, arcing, thermal damage) as well as chemical contamination (transformer under vacuum, no nitrogen blanket, rust). These tests provide an indication of transformer aging over time and possible failure.

10.3.3 Selection Criteria of Substation Transformers

TWN developed a list of criteria for oil sampling of an energized transformer. This list was provided to each base. TWN and the Base CE determine the transformers for the study.

The criteria for oil sampling of an energized transformer consists of the following:

- Main tank shall indicate positive pressure. If the unit is under a vacuum and a gas fill valve and main tank pressure gauge is available, nitrogen pressure can be added while the unit is energized. If tank pressure cannot be determined due to the unit not having a pressure gauge or it is not legible the sample cannot be pulled until the unit is de-energized. Opening of the bottom valve under vacuum will produce air bubbling which can cause possible flash overs.
- Main tank oil level gauge shall be legible and indicate enough oil is available for the sample to be taken without causing issues.
- Main tank sampling valve shall be accessible without having to manipulate energized cabling.

Additional consideration (requirements) in the selection is:

- Is there a sample valve available and accessible?
- Are oil level and tank pressure gauges available?
- Is the unit considered critical to the operation and serve loads without redundant sources?
- Is the unit leaking?
- Is the exterior of the tank degraded and suspected of possible moisture intrusion?
- Is the exterior of the transformer showing signs of paint discoloration caused by overheating?
- Has the unit experienced multiple through faults?
- Has the unit shown signs of deterioration during electrical testing?

10.3.4 Standard Oil Sample Tests

TWN utilizes the services of SDMyers for oil sample testing. TWN plans to utilize two (2) of SDMyers testing packages. The first package, SDMyers No. 4003, is for transformers under 10MVA and the second package, SDMyers No. 4002, is for transformers over 10MVA. The tables

below describe the content of each testing package. Detailed definitions of individual tests and methods can be found in Volume II, Appendix A.

Table 10-3
SDMyers Testing Package 4003, Transformers <10MVA

SDMyers Testing Package 4003 for Transformer Below 10MVA	
Item	Test Type
1	Oil Screen Package (OS)
2	Dissolved Gas Analysis (DGA)
3	Karl Fischer Moisture (KF)

Table 10-4
SDMyers Testing Package 4002, Transformers >10MVA

SDMyers Testing Package 4002 for Transformer Greater than 10MVA	
Item	Test Type
1	Oil Screen Package (OS)
2	Dissolved Gas Analysis (DGA)
3	Karl Fischer Moisture (KF)
4	Liquid Power Factor (PF)
5	Oxidation Inhibitor Content (DBPC)

10.3.5 Issues Found During Field Data Collection

When performing oil sampling (drawing transformer oil sample) in the field TWN may encounter several issues that limit and/or prevent the transformer oil sample from being taken. These issues/factors may include the following, but may not be limited to the listed:

- No access to oil sampling valve due to secondary cables and other obstructions.
- Limited space, secondary bus location limits access.
- Transformer owned by the Utility.
- No vacuum and pressure gauges and/or indicator.
- Transformer under vacuum.
- Low oil levels.
- Oil sample valve damaged.
- Severe/extreme tilting of the transformer.

10.3.6 Transformer Oil Sampling Results

Transformers and associated maintenance provide an essential function in any power system. To maintain effective operation, it is imperative to monitor the condition of transformers through appropriate testing and routine oil sampling.

Oil Sampling has been De-Scoped from this study because all substation transformers are owned and operated by the utility company, AEP Texas. Thus, no Substation transformers were sampled.

Table 10-5 Oil Sampling Limitations Definitions:

- Oil Sample Drawn (Acceptable): No issues were found with the transformer and all selection criteria were met that allowed for the oil sample to be drawn and tested.
- Oil Sample Drawn (Questionable): Some potential issues with the transformer were found in the test results and all selection criteria were met that allowed for the oil sample to be drawn and tested.
- No Access: No access to the oil sampling valve due to secondary cable and/or other obstructions. Safety hazard to personnel. No oil sample drawn.
- Limited Space: The space between the energized bushings and the oil sampling valve were deemed too close and posed a safety issue to personnel. No oil sample drawn.
- No gauges: The transformer had no gauges to measure oil level, pressure, and/or temperature. No oil sample drawn. Consideration for replacement should be given.
- XFMR Under Vacuum: The transformer is under vacuum and presents a danger to equipment and personnel drawing the oil sample. No sample drawn. Transformer maintenance is recommended.
- Low Oil Level: The transformer has low oil levels and presents a danger to equipment and personnel drawing the sample. No sample drawn. Transformer maintenance is recommended.
- XFMR Valve Damaged: Oil sampling valve is damaged and presents a danger to equipment and personnel drawing the oil sample. No sample drawn. Transformer maintenance is recommended.
- XFMR Tilt Issue: Transformer is at a severe tilt (angle) and presents a danger to equipment and personnel drawing the oil sample. No sample drawn. Transformer maintenance is recommended.

10.4 Thermal Imaging (IR) (Transformer)

10.4.1 Performance Work Statement (PWS)

For each of the Substation transformers coordinated with the BCE (Base Civil Engineering), TWN will perform a thermal Imaging (IR) inspection during preliminary data gathering in accordance with NETA MTS and NFPA 70B.

10.4.2 Purpose of Thermal Imaging (IR) Inspection

Thermography is the use of an infrared imaging and measurement camera to “see” and “measure” thermal energy emitted from an object. Infrared thermography cameras produce images of invisible infrared or “heat” radiation and provide precise non-contact temperature measurement capabilities. Nearly everything gets hot before it fails, making infrared cameras extremely cost effective, valuable, predictive tools.

What is light energy? Consider, light is a form of electromagnetic radiation, a type of energy that travels in waves. Other kinds of electromagnetic radiation that we encounter in our daily lives include radio waves, microwaves, and X-rays. The seven (7) wavelengths that make up the electromagnetic spectrum are radio waves, microwaves, infrared, optical, ultraviolet, and gamma waves. Together, all the types of electromagnetic radiation make up the electromagnetic spectrum. Every electromagnetic wave has a particular wavelength, or distance from one crest to the next, and different types of radiation have different characteristic ranges of wavelengths (as shown in the diagram below). Types of radiation with long wavelengths, such as radio waves, carry less energy than types of radiation with short wavelengths, such as infrared. The complete electromagnetic spectrum can be seen in Figure 10-6 Electromagnetic Spectrum Graph. The infrared spectrum can cover a very large area for applications, be they medical, mechanical, electrical, security, etc. A large section of applications can be viewed in figure 10-7 Therma (IR) Application Chart.

Figure 10-6
Electromagnetic Spectrum Graph

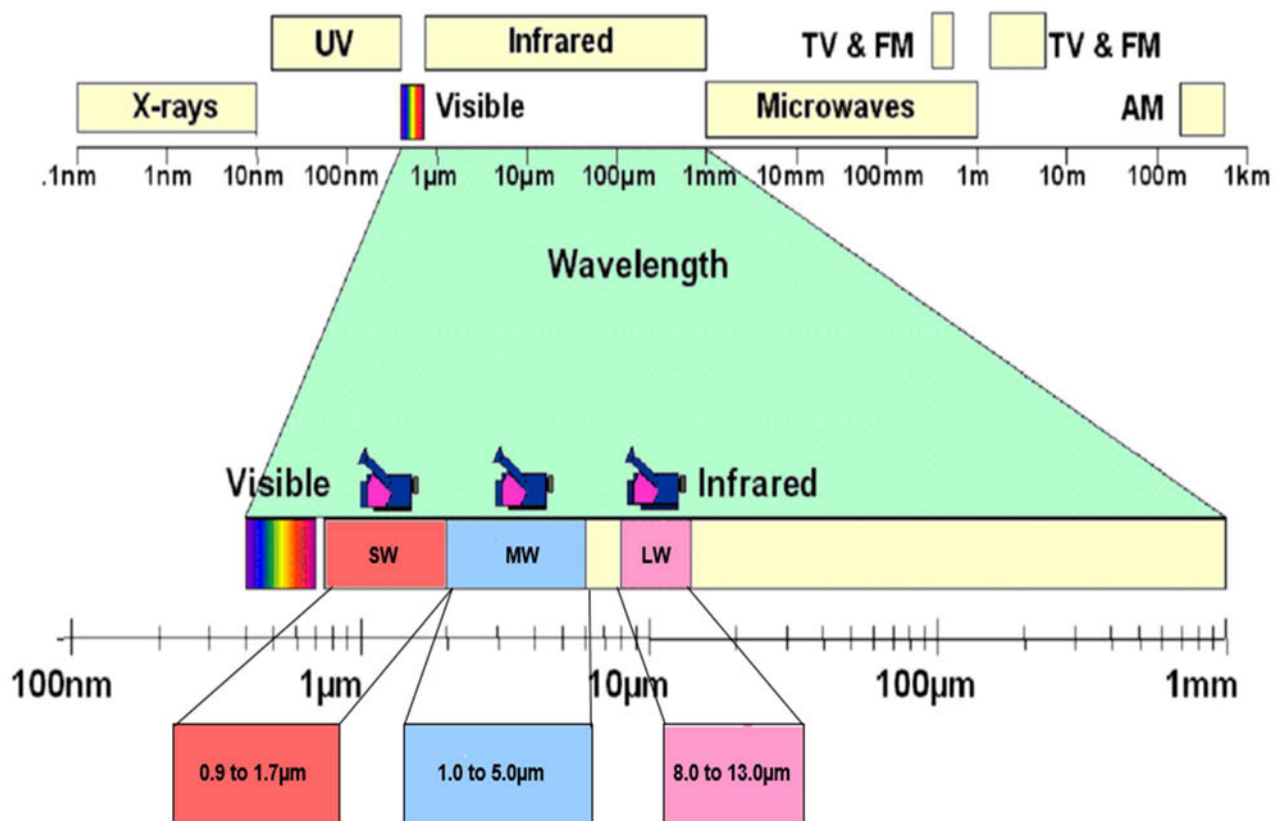
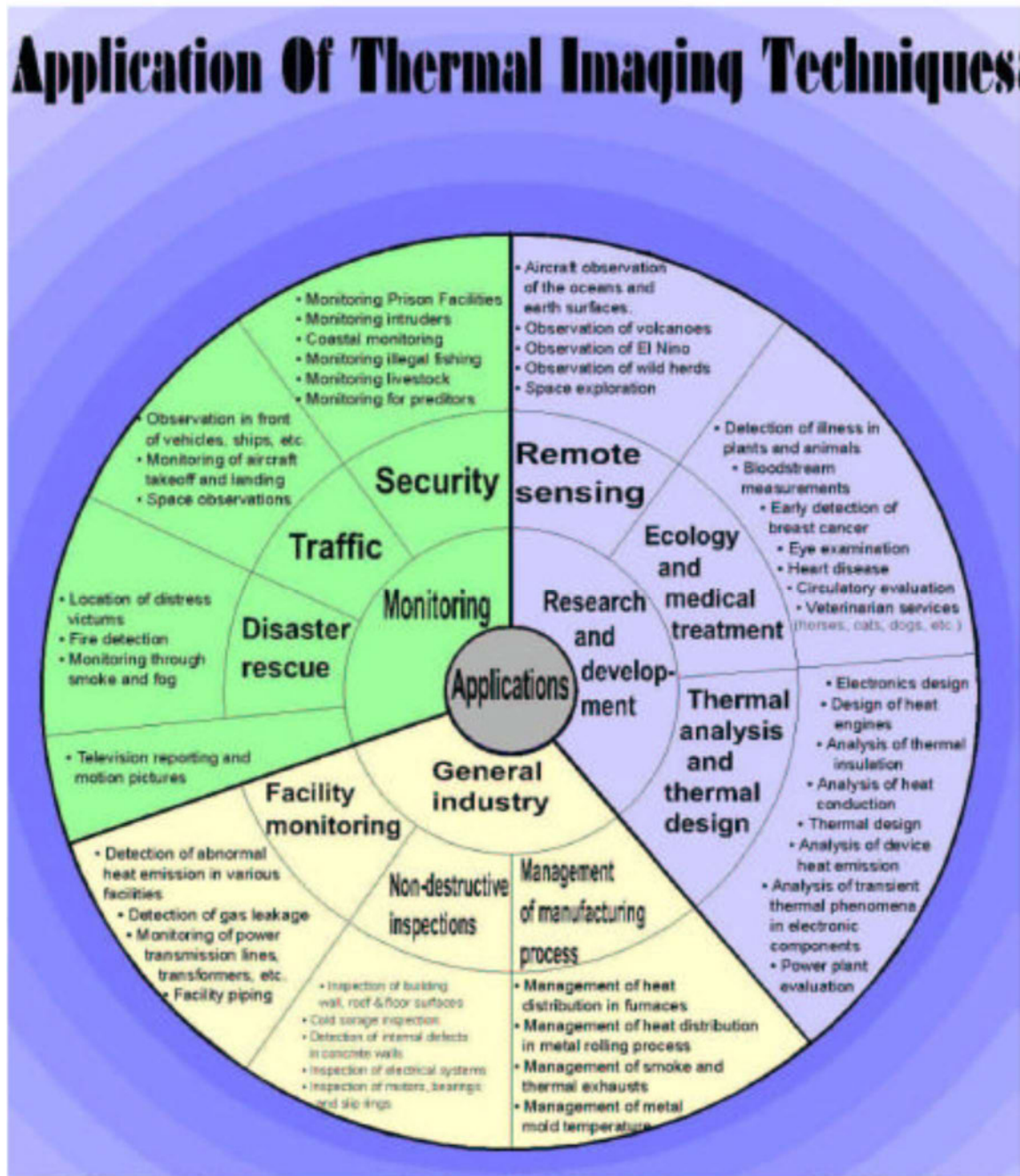


Figure 10-7
Thermal (IR) Application Chart



10.4.3 Thermal Imaging (IR) Inspection Results

TWN did not perform a thermal imaging (IR) inspection on the substation transformers as all substation transformers are owned and operated by the utility company, AEP Texas.

11

PROJECT RECOMMENDATIONS

Section 11 addresses a variety of topics intended to improve the primary distribution system.

11.1 Electrical System Infrastructure Recommendations

In the analysis, documentation, field data, future infrastructure projects, and study results, deficiencies have been identified and resolutions (project) are provided. Section 11.2 – Table 11-1 provides a summary of the recommendations (outlined below) and budgetary estimates.

11.1.1 *Replacement of over duty equipment*

Electrical distribution equipment that is shown to be over duty should be removed from service until actions are taken to remove the over duty conditions. Refer to Section 1.4.2 for interrupting rating and short-circuit current rating criteria per NFPA 70-2023. There were Thirty-Six (36) pieces of equipment that are considered overdutied, which should be replaced as soon as possible. There are also Nine (9) pieces that have warnings, which indicate it's within 10% of the Short Circuit rating and these should also be replaced as soon as possible. Recommendations are provided in Table 11-1.

11.1.2 *Peak Loading Study*

There are three (3) transformers that currently do not meet NEC 450.3 (T9018, T1-24, and T6222). Due to limitations of scope, TWN does not perform an extensive peak loading study per building therefore, a peak loading study is recommended to ensure the accuracy of the peak load per service entrance. This would allow for proper sizing of each service entrance. Some possible recommendations could be:

- Increase the size of the transformer.
- Feed load from another source.

11.1.3 *Power Factor Study*

From the instantaneous spot measurements taken during data collection, there are sixty-four (64) transformers with a power factor less than 90%. The reasons a transformer could have a power factor less than 90% are as follows:

- Light loading.
- Electronics drawing a large portion of the load.
- Unbalanced phases.

- Current draw from an induction motor.
- Harmonic currents.

Solutions to fix power factor issues include:

- Installing a capacitor bank.
- Balancing phases.
- Installing a VFD for induction motors

The Dranetz measurements taken show that the transformers seem to not have an issue with phase imbalance or harmonics. Installing a capacitor bank at these locations could improve power factor. With the limitations that come with the scope of this power system study (i.e. instantaneous measurements) it is difficult to say with certainty that there is a true power factor issue at these locations. Therefore, an in-depth power factor study is recommended for these locations.

11.1.4 Add cable tags to all HV and LV Cable

Cable tags should be added to all HV and LV cables. This should include information such as cable size and to/from information.

11.1.5 Ground Study of Installation

An important aspect of any electrical system is the earth grounding. A study should be performed periodically to verify the following:

- The existing earth grounding system complies with the original design.
- Changes to the existing earth grounding system have been properly recorded.
- The earth grounding system performs as designed and/or acceptable standards.

Given the observed condition of the equipment and changes that have been made in the system, a ground study would be beneficial.

11.1.6 Arc Flash Mitigation - upgrade protective device for an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT))

Installation of intelligent electronic devices (IEDs), to replace the existing solid state trip (SST) units, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)). The solution is activated to mitigate the arc flash hazard by limiting the duration of the fault current to the fault, using a user selectable and settable secondary instantaneous pickup setting.

This solution can also be added to existing panelboards and/or in front of the service entrance. This provides another means of engineering control of elevated arc flash levels.

11.1.7 Bravo and Alpha Substation/Switching Station Upgrades

The current condition of the Alpha and Bravo Substations is recognized as being very poor, with equipment showing significant wear due to exposure to sun and sand. Additionally, the Bravo Circuit, in its current configuration, will not be able to handle the new load from the upcoming B-21 Project. Therefore, it is recommended that both the Alpha and Bravo Substations/Switching Stations be redesigned to accommodate these new loads. The budgetary estimate provided in Table 11-1 for this recommendation is a high-level estimate.

11.1.8 Arc Flash Training

Provided NFPA 70E based arc flash hazard training to installation personnel.

The training class provides the following (at a minimum):

- One (1) day, up to eight (8) hours of instruction
- Training materials / book
- NFPA 70E introduction
- OSHA – MSHA and other Authorities
- Arc flash basics.
- Current electrical system overview
- Installation known and potential areas of risk.
- Corrective techniques and safe working environments
- Incident energy level and PPE requirements
- Documentation, training, and responsibilities

11.2 Recommendations and Budgetary Estimates

The following represent the recommendations and budgetary estimates.

Table 11-1
Recommended Electrical Infrastructure Projects

Index	Projects & Recommendation	Budgetary Estimate (\$)	Expanded Overview Supporting Recommendation
	PROJECTS		
1	Cable Tags		Limited cable tags were found during Data Collection. Cable tagging recommended inclusive of: Development of naming convention and individual labels, purchase of materials, printers, etc. Installation of label tracing cable to and from locations. Estimate for # of cables: 1,268 resulting in 2,536 tagging locations.
2	Alpha and Bravo Substation		Upgrading Alpha and Bravo Substations would significantly enhance their capacity to handle the upcoming load and reduce equipment wear and tear. Please note that this estimate is preliminary, and additional details are required to provide a more accurate budgetary estimate.
3	Label Manholes		Several unnamed Manholes were found during Data Collection. This project includes: - Development of naming convention to facilitate equipment tracking and their respective individual labels. Also, includes purchase label materials, printer, etc. - Installation and tack weld labels.
	Replacement of overdutied equipment (Svc Entrance / Bkr / Panel)	Budget Represent s 46 Locations	Overduty equipment requiring replacement (Price is per breaker).

4	B95S1-1 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
5	B95S1-2 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
6	B95S1-3 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
7	B95S2-2 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
8	B95S2-3 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
9	B95S2-4 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
10	B95S2-5 IN	Replace Panelboard . 20kA	██████	Violation: Overduty Rated at 10kA

		minimum rating		
11	B95S2-6 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
12	LVB-B4201 (MAIN)	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
13	B4201 (B) OUT	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
14	B4218 SE2 (MLO)	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
15	B5015 (MDP MLO)	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
16	B5130 OUT	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA

17	B5280 OUT	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
18	B6137 SE2	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
19	LVB-B7106B SE2	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
20	B7106B SE2 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
21	B7206 (PANEL M) SE1 OUT	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 14kA
22	B7206 SE2	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
23	B7206 IN	Replace Panelboard . 20kA	██████	Violation: Overduty Rated at 10kA

		minimum rating		
24	FDSC-B7216	Replace Fuses. Minumum 20kA rating	████	Violation: Overduty Rated at 10kA
25	B7216 IN	Replace Panelboard . 20kA minimum rating	████	Violation: Overduty Rated at 10kA
26	B7218A SE1 OUT	Replace Panelboard . 20kA minimum rating	████	Violation: Overduty Rated at 10kA
27	LVB-B7416	Replace Panelboard . 20kA minimum rating	████	Violation: Overduty Rated at 10kA
28	B7416 (PANEL A) IN	Replace Panelboard . 20kA minimum rating	████	Violation: Overduty Rated at 10kA
29	B8006 SE2 OUT	Replace Panelboard . 20kA minimum rating	████	Violation: Overduty Rated at 10kA

30	LVB-B8011 SE1	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
31	B8011 SE1 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
32	LVB-B8080A	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
33	B8080A IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
34	LVB-B11955A SE1 (MAIN)	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
35	B11955A SE1 (PNL A) IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
36	LVB-B11955A SE2 (MAIN)	Replace Panelboard . 20kA	██████	Violation: Overduty Rated at 10kA

		minimum rating		
37	B11955A SE2 (PNL B) IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
38	LVB-B11955A SE3	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
39	B11955A SE3 IN	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
40	B11955A SE4 (MLO)	Replace Panelboard . 20kA minimum rating	██████	Violation: Overduty Rated at 10kA
41	B11955B (MLO)	Replace Panelboard . 20kA minimum rating	██████	Warning: Overduty Rated at 10kA
42	BP4218 SE1 OUT	Replace Panelboard . 20kA minimum rating	██████	Warning: Overduty Rated at 10kA

43	B-BOMBPAD OUT	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 10kA
44	LVB-B-RAMP4	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 10kA
45	B-RAMP4 IN	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 10kA
46	LVB-B4202 (MISSION ESSEN.)	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 10kA
47	B5020 IN	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 14kA
48	LVB-B7233 SE1B	Replace Panelboard . 20kA minimum rating	████	Warning: Overduty Rated at 10kA
49	B7233 (7-05) SE1B IN	Replace Panelboard . 20kA	████	Warning: Overduty Rated at 10kA

		minimum rating		
	Breaker / Fuse Replacement / Sizing (Coordination / Sizing Considerations)		 Budget Represent s 126 Locations	Replacements recommended due to sizing and/or coordination or Arc Flash
50	P-B4-68	See Table 9-1 for more information.		To better coordinate with downstream equipment, we felt that the size and type of the "Transformer Fuse" should be brought down in order to better protect the transformer.
51	P-B1-L3-19	See Table 9-1 for more information.		To better coordinate with downstream cable C-P-B1-L3-19 - JB1-040, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMRs.
52	P-B1-L3-24	See Table 9-1 for more information.		To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
53	P-B1-L5-4	See Table 9-1 for more information.		To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
54	P-B1-L5-5	See Table 9-1 for more information.		To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.

55	LVB-B4112	See Table 9-1 for more information.	██████	To better Coordinate with downstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
56	P-B4-35	See Table 9-1 for more information.	██████	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
57	LVB-B9329 S3	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
58	FU-T6136B BAY	See Table 9-1 for more information.	██████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
59	FU-T6136B	See Table 9-1 for more information.	██████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
60	FU-T7004A BAY	See Table 9-1 for more information.	██████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.

61	FU-T9350 BAY	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
62	FU-T-LT22 BAY	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
63	FU-T-LT22	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
64	FU-T-LT23 BAY	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
65	FU-T-LT27 BAY	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
66	FU-T-LT28 BAY	See Table 9-1 for more information.	████	To better coordinate with downstream equipment, we felt that the size of the "Transformer Fuse" should be brought up and use Dual Element fuses instead of Current Sensing fuses, in order to better protect the transformer.
67	LVB-B5111 (PNL Y)	See Table 9-1 for more	████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

		information.		
68	LVB-B7316B	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
69	P-B4-77	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.
70	LVB-B9203 SE1 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.
71	LVB-B8140	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
72	LVB-B11959 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
73	LVB-B8202B (HDP)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.

74	P-C2-10	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR. The "Fuse-Cutout" was also brought down in order to better protect the transformer.
75	LVB-B-62	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
76	LVB-B-63	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
77	LVB-B-64	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
78	LVB-B-66	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
79	LVB-B-67	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
80	LVB-B-69	See Table 9-1 for more	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

		information.		
81	LVB-B-70	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
82	LVB-B-71	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
83	LVB-B-73	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
84	LVB-B-74	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
85	LVB-B-75	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
86	LVB-B-76	See Table 9-1 for more information.		To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

87	LVB-B-77	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
88	LVB-B-78 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
89	LVB-B-80	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
90	LVB-B-81	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
91	LVB-B-82	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
92	LVB-B-83	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
93	LVB-B-84	See Table 9-1 for more	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

		information.		
94	LVB-B5013 (MSB)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
95	LVB-B4314 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
96	LVB-B-C10	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
97	LVB-B-C11 SE1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
98	LVB-B-C5 SE1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
99	LVB-B-C6	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

100	LVB-B-C7 SE1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
101	LVB-B-C8	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
102	LVB-B-C9	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
103	LVB-B95S1-1 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
104	LVB-B95S1-3 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
105	LVB-B95S2-2 (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
106	LVB-B95S2-4 (MAIN)	See Table 9-1 for more	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

		information.		
107	LVB-B-B4	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
108	LVB-B-B8	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
109	LVB-B-C3	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
110	LVB-B5020	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
111	LVB-B7007B	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
112	P-B2-46	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

113	LVB-B7008A (MAIN)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
114	B7223-CH1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
115	B7223-CH2	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
116	LVB-B5224B (MAIN NO.2)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
117	LVB-B8031	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
118	LVB-B7104 (MDP)	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
119	P-C4-L5-34	See Table 9-1 for more	██████	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.

		information.		
120	P-C3-15	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought down in order to better coordinate with the downstream XFMR.
121	P-B4-90	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
122	FSW-P-B3-L2-6	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
123	P-B3-L2-7	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR.
124	FSW-P-B4-62	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with transformer protection.
125	LVB-B9219 (MAIN)	See Table 9-1 for more information.	■	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with transformer protection.

126	P-C3-19A	See Table 9-1 for more information.	██████	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with motor protection.
127	LVB-B5112 (MSB) SE1	See Table 9-1 for more information.	██████	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with motor protection.
128	LVB-B5112 (CHILLER1)	See Table 9-1 for more information.	██████	To better Coordinate with downstream equipment, we felt that the size of the "Fuse-Cutout" should be brought up in order to better coordinate with the downstream XFMR. Also the "LV Breaker" was adjusted to better coordinate with motor protection.
129	FDSC-B5142 SE1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "FSDC (Fuse Disconnect)" should be brought down in order to better coordinate with the Upstream XFMR.
130	LVB-B6115	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
131	LVB-B6119	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
132	LVB-B6122A	See Table 9-1 for more	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

		information.		
133	LVB-B6122B	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
134	LVB-B6123	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
135	LVB-B7403	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
136	B7407	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
137	LVB-B7409 (D-07) SE1	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
138	LVB-B7421	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.

139	LVB-B8215	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
140	LVB-B5105	See Table 9-1 for more information.	██████	To better Coordinate with upstream equipment, we felt that the Instantaneous settings of the "LVB" should be brought down in order to better coordinate with the Upstream XFMR.
141	LVB-B7000A	See Table 9-1 for more information.	██████	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.
142	LVB-B7000B	See Table 9-1 for more information.	██████	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.
143	LVB-B7234	See Table 9-1 for more information.	██████	The distribution system has arc flash issues at this location. LV Circuit Breaker settings were adjusted to lower arc flash ratings in this location.
144	FDSC-B7302 (SERVICE DICCONNECT)	See Table 9-1 for more information.	██████	The distribution system has arc flash issues at this location. Fuse Type was adjusted to lower arc flash ratings in this location.

145	C-B4127 SE3	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B4127 SE3 should be sized up to better fit the fused service entrance FDSC-B4127 SE3.
146	C-B4202 (PANEL D) SE2	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B4202 (PANEL D) SE2 should be sized up to better fit the fused service entrance FDSC-B4202 (PANEL D) SE2.
147	C-B4202 (PANEL D) SE2	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B9045 SE1 should be sized up to better fit the fused service entrance LVB-B9045 SE1.
148	C-B8211 (SERVICE DISC.)	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B8211 (SERVICE DISC.) should be sized up to better fit the fused service entrance LVB-B8211 (SERVICE DISC.).
149	C- B-BOMBPAD	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B-BOMBPAD should be sized up to better fit the fused service entrance B-BOMBPAD.
150	C-B9329 SE1	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cables C-B9329 SE1 and C-B9329 SE3 should be sized up to better fit the respective service entrance.
151	C-B9329 SE3	See Table 9-2 for more		To better meet NEC Standard 310.16, we felt that the cables C-B9329 SE1 and C-B9329 SE3 should be sized up to better fit the respective service entrance.

		information.		
152	C-B7007B	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B7007B should be sized up to better fit respective service entrance.
153	C-B7008A (MAIN)	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B7008A (MAIN) should be sized up to better fit respective service entrance.
154	C - B7104	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B7104 should be sized up to better fit respective service entrance.
155	C - B-LT12	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B-LT12 should be sized up to better fit respective service entrance.
156	T6030A	See Table 9-2 for more information.		While there is no violation at this location, it is recommended to add primary protection to the Junction Box JB2-27, T6030A, or T6030B. This will allow for faults at either of those locations to be cleared locally.
157	T6030B	See Table 9-2 for more information.		While there is no violation at this location, it is recommended to add primary protection to the Junction Box JB2-27, T6030A, or T6030B. This will allow for faults at either of those locations to be cleared locally.

158	C - B4300 SE3	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B-B4300 should be sized up to better fit respective service entrance.
159	C-B5138 (LIGHT POLE) SE3	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cable C-B-B5138 (LIGHT POLE) SE3 should be sized up to better fit respective service entrance.
160	C-B8013 SE1	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cables C-B8013 SE1 and C-B8013 SE4 should be sized up to better fit respective service entrance.
161	C-B8013 SE4	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cables C-B8013 SE1 and C-B8013 SE4 should be sized up to better fit respective service entrance.
162	C-B9121A SE1	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the cables C-B9121A SE2 should be sized up to better fit respective service entrance.
163	B5110A SE1 OUT	See Table 9-2 for more information.		The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).

164	B5224B (MAIN NO.2) OUT	See Table 9-2 for more information.		The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
165	B6030B OUT	See Table 9-2 for more information.		The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
166	B7008C (SWBD MA) OUT	See Table 9-2 for more information.		The distribution system has arc flash issues at this location. Implementation of Intelligent Electronic Devices, to replace the existing SST, provides the added benefit of an energy reduction solution (such as: maintenance mode, reduced energy let through (RELT)).
167	TR-61	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
168	TR-62	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
169	TR-64	See Table 9-2 for more information.		To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.

170	TR-66	See Table 9-2 for more information.	██████	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
171	TR-67	See Table 9-2 for more information.	██████	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
172	TR-74	See Table 9-2 for more information.	██████	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
173	TR-83	See Table 9-2 for more information.	██████	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
174	TR-84	See Table 9-2 for more information.	██████	To better meet NEC Standard 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment or the correct size of cable needed at this service entrance.
175	T6222	See Table 9-2 for more information.	██████	To better meet NEC Standard 450.3 and 310.16, we felt that the transformer could use a load study. This will allow the base to come up with the correct size of protective equipment and cable needed at each service entrance.

	Maintenance, Repair and Replacements		Budget Represent s 625 Locations	Material Condition: The existing Transformers and Service Entrance panels are in various states of disrepair. They are missing fasteners, shows signs of corrosion, missing dead-fronts, and/or not installed per the manufacturer's instructions. They should be repaired and maintained.
176	BC4-L4-6			Dirty
177	T8020			Dirty, Feces
178	T8131			Dirty, Weeds, Webs
179	T8080B			PF, Dirt, Dirty, Webs
180	B8080B			Dirt & Dirty
181	B8040A SE1			Dirty
182	B8040A SE2			Dirty
183	T5204B			Dirty, Webs
184	T5209			Webs, Dirty
185	T-RAMP29			PF, Dirty, Webs
186	BC4-L9-1			Webs, Dirty
187	B-TP9018 SE2			FDMU, Dirty
188	T9024			Webs, Dirty
189	JB1-040			Webs, NT
190	JC4-010			Dirty
191	T8006			Dirty, PF
192	T8013			Dirty
193	T7008C			Webs, Dirty
194	JB2-320			Dirty, NT
195	B7008C			Min Corr, Webs
196	B7007A SE2			Cant read fuses
197	T7010			Min Corr, Dirty
198	B7238 SE1			Dirty

199	JB2-210				NT, Dirty
200	T7234				Dirty, Min Corr
201	T7233				Weeds, Dirty
202	JB2-240				Dirty, Min Corr, plastic bags around conductors
203	T5005A				Dirty
204	T5003A				Min Corr
205	T5020				PF, Dirty, Leaves
206	T7040				Dirty
207	JB2-180				Loops, Webs, Dirty, NT
208	JB2-170				NT, Webs, Dirty
209	JB2-160				NT, Webs, Dirty
210	JB2-150				NT, Webs, Dirty
211	T7004B				Min Corr, Webs, Dirty
212	B7004C SE2				Dirty
213	T7000B				PF, Dirty
214	SW-32				NT, Webs, Dirty
215	SW-31				NT, Webs, Dirty, Nests
216	B11990				Dirty
217	SW-33				Webs, Dirty, Missing Bushing Cover, Cut Wire
218	SW-34				Webs, Dirty
219	TR-90				Dirt, Webs
220	B-RAMP3 SE2				Dirty
221	B-RAMP5				225A, NPS
222	B-RAMP7				Dirty
223	B-RAMP13				Dirty
224	B-RAMP18				Dirty
225	B-RAMP19				Dirty
226	B-RAMP21 SE2				NPS

227	B-RAMP21 SE1				Dirty
228	B4170A				NPS
229	T4316B				Dirty, Webs
230	B4112				NPS
231	T4230				Webs, Dirty
232	T4225				Webs, Dirty
233	T11751E				Dirty, Weeds
234	T11751A				PF, Webs, Dirty
235	B11751D				Min Corr, Dirty, PF
236	T11751F				Webs, Dirty, Dirt
237	T6117				Dirty
238	T6119				Dirty, Dirt
239	T6123				Dirty
240	B6123				Dirty
241	T6125B				Dirty
242	B6125 SE1				Dirty
243	T6127A				Weeds, Dirty
244	T6132				Dirty, Webs
245	B6132				DFAC, Dirty, Webs
246	B6136A SE1				Dirty, Webs
247	B6136A SE2				Dirty
248	T6130				Dirty
249	T6137				Dirty
250	T6138B				Dirty
251	JB2-090				Webs, Dirty, No Tags
252	B5142 SE1				Dirty
253	B5138 SE1				Dirty
254	T5111				Webs, Dirty

255	T5110B				Webs, Dirty
256	T5108B				Dirty
257	T4312				Webs, Dirty
258	T4315				Dirty, Webs
259	B4315 SE1				Dirty
260	B4316A SE2				dirty
261	T4216				Dirty
262	T4218				Dirty, Dirt, Hole
263	b4218 se3				NPS, Dirty
264	T9110				Dirt, Dirty
265	T9114B				Dirty
266	B9135				Dirty
267	T-LT22				Webs, Dirty
268	T9165				Dirty, PF
269	T9169				Dirty, Dirt
270	T-LT23				Dirty
271	B-LT23 SE1				Dirty, Inside left of LV compartment
272	T9045				Dirty
273	T9121B				Min Corr, Dirty, Webs
274	T-BOMBPAD				Min Corr, Webs, Dirty
275	B9222				Dirty
276	T9219				Dirty, Webs
277	B-LT3				PF, NPS
278	T-LT12				Dirty, Webs
279	B9153A				NPS
280	T9330				Dirty
281	TP9104 SE3				Dirty
282	B9190 SE1				Min Corr, Dirty

283	B9190 SE1A				Min Corr, Dirty
284	T9304				Dirty, Webs
285	T9305				Dirty, Webs
286	JC2-040				Webs, Dirty
287	T7116				No Load, Weeds, Dirty, webs
288	JC2-030				Dirty
289	T7110				Dirty
290	B7110				Dirty
291	T7106A				Dirty
292	T7298				dirty
293	T6220				Dirty
294	JC2-260				Dirty
295	T6222				Dirty
296	T7403				Dirty Webs
297	T7421				Dirty
298	T7409				Tilt, Dirty
299	B7409 SE2				Dirty
300	T7340				Dirty MiN Corr
301	B7340 SE2				Dirty
302	T7339				Min Corr, PF, Dirty
303	JC2-070				Dirty, Webs, NT
304	JC2-060				Dirty, NT
305	T7216				Dirty, Webs, PF
306	T7215				Dirty, Grass Clipping
307	T7217				Diryt
308	B7217				Dirty
309	T7223				Dirty
310	B7316A SE1				Dirty, can not open energized,

311	B7316A SE2			Dirty
312	T7316B			Dirty
313	T7206			Dirty
314	JC2-060			Loop, NT, Dirty
315	JC2-080			Loop, NT, Dirty, PF
316	JC2-090			Loop, NT, Dirty, Webs, Corr, PF
317	T7320			Dirty, Webs
318	T8150			Dirty
319	SC2-020			Dirty, NT
320	T8202B			Dirty
321	T8202A			Dirty
322	JC2-170			Loop, NT, Dirty
323	T8211			PF, Min Corr, Dirty
324	JB2-270			NT, Dirty, Webs
325	JB2-280			Dirty, Webs
326	JB2-290			Dirty, Loop, NT
327	JB2-300			Loop, Dirty, NT
328	T6030D			PF, Corr, Dirty
329	JB2-130			NT, Dirty
330	JB2-140			NT, Dirty
331	JB2-220			NT, Dirty
332	JB2-230			NT, Dirty
333	JB2-250			Dirty, NT
334	SW-30			Dirty, Webs
335	SW-29			Dirty, Dirt
336	SW-28			Dirty, Webs, Dirt
337	SC-27			Dirty, Webs,
338	SW-26			Webs, Dirty,

339	SW-23				Webs, Dirty,
340	SC-8				Weeds, Webs, Dirty
341	SW-8				Webs, Dirty, Dirt
342	SW-9				Webs, Dirty
343	SW-10				Tilt, Webs, Dirty
344	SC-39				Dirty
345	B11902				School, NPS
346	SW-11				Dirty, Webs
347	SW-12				Dirty, Webs
348	SW-13				Dirty, Webs
349	T11905				Dirty, Weeds
350	SC-13A				Dirty
351	SW-14				Dirty
352	SC-16				Webs, Dirty
353	SW-16				Webs, Dirty
354	SC-15				Dirty, Dirt, Webs, Nest
355	SW-15				Dirty, Webs, Nest
356	T-LT9				Webs, Dirty
357	T-LT10				Webs, Dirty
358	T-LT11				Webs, Dirty
359	SW-39A				webs, Dirty, NT
360	SC-17				webs, Dirty, NT
361	SW-17				Webs, Dirty
362	T1-24				Dirty, Webs, Dirt
363	B1-24 SE7				Dirty
364	T1-23				Dirty, Weeds, Dirt
365	T1-19				Wees, Dirt
366	T1-18				Webs, Dirt

367	T1-38				Webs, Dirty
368	T1-34				Webs, Dirt, Tilt
369	T1-33				Webs, Dirt, Tilt
370	T1-32				Dirty, PF
371	SW-78				Webs, Dirty, NT
372	SC-7				Webs, Dirty
373	SW-7				Webs, Dirty
374	SC-6				Webs, Dirty
375	SW-6				Webs, Dirty, Dirt, Titl
376	SC-40				Webs, Dirty
377	SW-40A				Webs, Dirty
378	B-40A SE1				Min Corr, Dirty
379	SC-4				Weeds, Webs, Dirty
380	SW-4				Ants, Dirt, Dirty, Webs
381	SC-3				Dirty
382	SW-3				Tilt, Webs, Dirty, Dirt
383	SC-2				Dirty, Dirt, Webs
384	SW-2				Dirty, Webs
385	B-1A SE1				Min Corr, Dirty
386	TC5				Webs, Dirty
387	BC5 SE2				Dirty
388	TC6				Webs, Dirty
389	BC6				NPS
390	BC9				PF, NPS
391	TC10				Dirty, Dirt
392	BC10				Dirty, NPS
393	TC11				Shrubs, PF, Dirty, Webs
394	BB3				PF, Dirty, NPS

395	TC3			PF, Dirty, Dirt
396	BC3			Dirty, PF, NPS, Door Locked but found open
397	TC1			PF, Dirty
398	TR-70			Dirty, Webs, Dirt
399	SC-38			Dirty
400	TR-69			Dirt, Webs, Dirty
401	SW-67			Dirty, Webb
402	TR-67			Dirty, Webs
403	TR-66			Webs, Dirty
404	TR-64			Dirty, Dirty, Webs
405	TR-63			Dirty, Webs
406	TR-62			Dirty, Webs
407	TR-61			Diryt, Webs
408	B-59 SE2			Dirty
409	TR-73			Ants, Dirt, Dirty, Webs
410	TR-74			Dirty, Webs, Dirt
411	TR-75			Dirty, Webs, Dirt
412	TR-76			Dirty, Webs, Dirt
413	TR-77			Dirty, Webs, Dirt
414	SW-77			NT, Dirty, Webs
415	T-57			Dirty, Webs
416	T1-58			Dirty, Webs, Dirt
417	T1-39			Dirty
418	T1-40			Dirty, Webs
419	T1-41			Dirty, Webs
420	T1-44			Dirty, Webs
421	T1-46			Dirty, Webs
422	T1-47			Dirty, Webs

423	T1-56			Dirty, Webs
424	T1-55			Dirty, Webs
425	T1-54			Dirty, Webs
426	TR-80			Dirty, Webs
427	TR-82			Dirty, Webs
428	SC-19			Dirty, Webs
429	SW-20			Dirty, NT
430	SC-21			Webs, Dirty
431	SW-21			Dirty, Turds
432	SW-22			Dirty, Webs, NT
433	T5-3			Dirty, PF
434	T5-1			Dirty
435	T5-4			Dirty
436	T1-6			Dirty, Weeds
437	T1-2			Dirty, Weeds
438	T1-1			Dirty, Webs
439	T95S1-2			Dirty, Webs
440	B95S1-2			Dirty, NPS
441	TB8			Dirty, Webs
442	BB8			Dirty, NPS
443	TB5			Webs, Dirt
444	TB4			Dirty, Webs, PF
445	BB4			PF, Dirty, NPS
446	B95S2-4			Dirty, NPS
447	T95S2-5			Webs, Dirty
448	B95S2-3			PF, Dirty, NPS, Locked/No Key
449	TA10			Dirty, Dirt
450	B95S2-2			PF, NPS, Dirty

451	T9265			Dirty
452	B-LT4			Min Corr, Dirty
453	Offsite Gen			Dirty, Webs, Min Corr
454	T-GENA (T-BESS-N)			No Secondary Conductors, Dirty, Webs, Min Corr
455	T8130B			Webs, Dirty
456	T8080A			PF, Dirty, Webs, Open Space
457	T8046			Corr, Dirt, Dirty, Webs, No Load, OOS
458	T5205			Dirty, Webs, Dirt
459	T5225			PF, Dirty
460	SC5-010			PF, Webs, NT
461	T-AIR1			No Load, Dirty, Webs
462	B5224B			Dirty
463	B5224A			OOS, Dirty
464	T5262			Dirty, Webs, PF
465	T-CASS2			Dirty
466	T5114			corr, Webs, Dirty
467	T5115			Dirt, Dirty
468	B-TPB1-34			Dirty, Webs
469	JC4-030			PF, Corr, Dirty
470	BC3-18B			PF, NS, Dirty
471	BC3-18A			Dirty
472	T9320			PF, dirty, Webs
473	SB3-010			PF, Dirty, NT
474	B-TP9104 SE1			NIS, Dirty, Cut Wires
475	B-TP9104 SE2			Dirty
476	T-FIRE2			Dirt, Webs, Weeds, Corr
477	B-FIRE2 SE1			Min Corr, Dirty
478	JB3-020			PF, Dirty, NT

479	JB2-100			PF, Dirty
480	T-LT1			PF, Dirty, Webs
481	T8011			PF, Dirty
482	B8011 SE3			Dirty
483	T8007			Dirt, Dirty, Webs
484	M7008D			Dirty
485	T-BALL1			Corr, Dirt, Dirty, No Load
486	T7230			No Load, Dirty, Webs
487	T8032			Dirty, Webs
488	T8030			Webs, Dirty, Trees, Bad Design
489	T5005B			PF, Dirty, Min Corr
490	T5003B			PF, Weeds, Dirt
491	T5004A			Webs, Dirty, Leaves
492	T5004B			OOS, Webs, Dirty, in Corr, PF
493	T7004C			Dirt, Dirty, PF, Webs
494	T7101			Dirt, Weed, Webs
495	B-SB4-010B			Dirty
496	T-SB4-010A			Webs, Dirty
497	SC-34A			J-Box, Webs, Dirty
498	SW-34A			Webs, Leaves, Dirty
499	SW-36A			Webs, Dirty, Partial Tags
500	B-36A SE1			Min Corr, Dirty
501	B-36A SE2			Min Corr, Dirty
502	SC-36			Dirty, Dirt, Webs
503	SW-36			Webs, Dirty, Dirt
504	SW-35A			Webs, Dirty
505	SW-45			Webs, Dirty
506	SW-44			Webs, Dirty

507	SW-43			Webs, Dirty
508	B-43A SE1			Min Corr, Dirty
509	B-43A SE2			Min Corr, Dirty
510	SW-42			Webs, Dirty
511	SW-40			Webs, Dirty, Dirt
512	SW-41			Webs, Dirty, Dirt
513	T-86			Webs, Dirty, No Load
514	SW-25			webs, Dirty, Dirt
515	T-87			Webs, Dirty
516	SC-24			Webs, Dirty, Dirt
517	SW-24			Webs, Dirty, Dirt, Min Corr
518	B-25A SE1			Min Corr, Dirty, FDMU
519	B-25A SE2			Min Corr, Dirty, FDMU
520	B-RAMP1			Webs, Dirty
521	B-RAMP3 SE1			Dirty, Webs
522	T-RAMP4			Webs, Dirty, Clippings
523	T-RAMP5			Corr, PF, Webs, Dirty
524	T-RAMP7			Webs, Dirty
525	T-RAMP13			PF, Corr, Webs, Dirty
526	T-RAMP16			Webs, Dirty
527	T-RAMP17			Webs, Dirty, PF
528	T-RAMP18			Webs, Dirty
529	T-RAMP20			Webs, Dirty, PF
530	T-RAMP21			PF, Webs, Dirty
531	T-RAMP22			Webs, Dirty
532	SC4-010			PF, Dirty, Webs, No Name Plate
533	T-RAMP24			Webs, Dirty, Hole in LV side
534	T-RAMP26			Webs, Dirty, PF

535	T-RAMP27			Webs, Dirty, Dirt
536	B9001			NPS
537	T4101			Dirty
538	T4300			PF, Dirty
539	T4201			Webs, Dirty, Grass Clippings
540	T4202			PF, Webs, Dirty, Grass Clippings
541	T11751D			Tilt, Dirty, Webs
542	B11751C			Dirty, Min Corr, Tilt
543	T-LIFT1			Webs, Dirty
544	T6115			Webs, Dirty, Dirt
545	SB3-015			Webs, Dirty, No Tags
546	T6122A			Dirty, Egress limited, Min Corr, PF
547	T6122B			Dirty, Min Corr, PF, egress limited
548	JB3-050			PF, Webs, Dirty, No Tags
549	JB2-060			Loop, No Tags, Dirty, PF, Corr
550	JB2-070			PF, Dirty, Webs, No Tags
551	T6141			Webs, Dirty, PF, Corr
552	T5138			Webs, Dirty, Dirt, PF
553	B5138 SE3			Dirty
554	B5138 SE2			Dirty
555	T5110A			Webs, Dirty
556	T5160			PF, Corr, Dirty, Dirt
557	T4323			Webs, Dirty
558	BP4218 SE2			NIS, Fuses Illegible
559	T9350			Dirty, Webs, PF
560	T-LT31			Webs, Dirty, No Load
561	JB4-010			Min Corr, Dirty
562	B9133			Dirty

563	B9132			NPS
564	T-LT27			Webs, Dirtys
565	T-LT28			Dirty
566	T-LT29			Dirty, Webs, PF
567	T9120			Webs, Dirty
568	B-LT23 SE2			Dirty, Webs
569	T9142			Dirty, Webs, Snake skin
570	SB3-060			NT, Dirty
571	T9121A			Webs, Dirty, Dirt
572	T-LIFT2			Webs, Dirt, Dirty
573	T9203			PF, Previous Arcing Even, Dirty
574	B9203 SE2			Dirty
575	T9222			Weeds, Webs, Dirty
576	B-B4-89 SE2			NIS, Dirty
577	T-LT3			Webs, Weeds, Dirty
578	B-LT12			Min Corr, Dirty
579	T9153A			Dirty, Dirt, Webs
580	T9198			Corr, Dirty
581	JC2-020			Moved off pad, webs, Dirty, NT
582	B7108 SE1			PF, FDMU, Dirty
583	B7403			Dirty, NPS
584	T7405			Dirty, Weeds
585	T7407			Dirty, Webs, PF
586	T7413			OOS, PF, Dirty,
587	SC2-010			PF, NT, Swtich, Dirty
588	JC2-100			Dirty
589	T7220A			Dirty, Dirt, Weeds
590	JC2-150			NT, Loop, Dirty

591	T7316A			Dirty, Corr, PF
592	JC2-200			Dirty, Loop NT
593	B-C2-L1-22			Corr, Dirty, Webs
594	T7318A			Webs, Dirty, Weeds
595	JB2-120			Dirty, Webs, PF, NT
596	T11913			PF, Webs, Dirty
597	T11902			PF, Min Corr, Dirty, Webs
598	T-LT5			Dirty, Webs, Lights, PF, Corr
599	T-LT6			Corr, PF, Dirty, Webs
600	B-LT6			Dirty, Webs, Hornets
601	B-LT7			Corr, Hole, Wasp Nest, Dirty
602	T-LT8			Dirty, Webs, Corr
603	B-LT8			Min Corr, Hole, Dirty, Webs
604	B-LT11			Dirty, Webs, Hole
605	T11955A			Webs, Dirty, Dirt
606	T11959			PF, Dirty, Webs, Nests
607	SC-18			Ants, Dirty, Dirt, Webs
608	T1-20			Webs, Dirty, Dirt
609	T1-21			Weeds, Webs, Dirt,
610	T1-37			Weeds, Dirty, Dirt
611	T-40A			Dirty, Dirt, Weeds
612	SW-1			Titl, Dirty, Webs
613	B-1A SE2			Min Corr, Dirty
614	BC8			NPS, PF, Dirty
615	TC7			PF, Webs, Dirty
616	BC7 SE1			Dirty, Webs, PF, NPS
617	TC9			PF, Dirty, Dirt, Weeds
618	BC11 SE1			Shrubs, Dirty, NPS

619	TC2				PF, Dirt, Dirty, Nests
620	TC4				PF, Webs, Dirty, Dirt
621	T1-59				Dirty, Webs, Dirt
622	T1-42				Dirty, Webs, Weeds, Dirt
623	T1-43				Dirty, Webs, Weeds, Dirt
624	T1-45				Dirty, Webs, Dirt
625	T1-48				Dirty, Webs, Dirt, Weeds
626	T1-52				Dirty, Webs, Dirt
627	T1-51				Dirty, Webs, Tilt
628	T14402				Dirty, Webs, Dirt
629	TR-81				Dirty, Webs, Dirt
630	T1-29				Dirty, Weeds, Dirt
631	T1-30				Dirty, Weeds, Dirt
632	T1-31				Dirty, Webs, Dirt
633	SW-19				Dirty, Webs, Tilt
634	T95S1-1				Dirty, Webs, PF
635	B95S1-1				PF, NPS, Dirty
636	SW-05S				Dirty, Dirt, Webs, NT
637	SC-95S5				PF, Webs, Dirty, NT, HV Cover
638	T1-3				Dirty, Weeds, Dirt
639	T1-11				Dirty, Weeds, Dirty
640	T1-12				Dirty, Weeds, Dirty
641	T1-13				Dirty, Weeds, Dirty
642	T1-15				Dirty, Webs, Dirty
643	T1-28				Dirty, Webs, Dirt
644	T1-27				Dirty, Webs, Dirt
645	B95S1-3				Dirty, PF
646	T95S2-6				Dirty, Webs, Dirt, PF

647	TB6			PF, Dirty
648	T95S2-4			Dirty, Webs
649	T95S2-3			Dirty, Webs, Dirt
650	T-LT4			Dirty, Dirt, Grass Clippings, Corr
651	T9118			No load, Webs, Dirty
652	B4230 SE2			NPS
653	T5160B			Webs, Dirty
654	JB3-070			Dirty, NT
655	T8130A			Tilt, Dirty, Webs, PF
656	BC5-17 SE1			Dirty, Webs, Wasps
657	B-AIR1			Dirty, Bkr no name plate, PF
658	T5212			Dirty, Past arcing event, PF
659	T5280			Webs PF, Corr, Tilt, Dirty
660	T9018			Corr, Dirty
661	TP8030			Corr, Dirty
662	SB1-010			Dirt, Dirty, Webs
663	B-BALL1			Corr, Dirty
664	T-SB4-010B			PF Corr, Webs, Dirty
665	T-89			Webs, Dirty, Dirt, No Load
666	T-25A			Webs, Dirty, Dirt, No Load
667	T-RAMP2			Webs, Dirty, Dirt
668	T-RAMP3			Webs, Dirty, Grass Clippings
669	T-RAMP23			Webs, Dirty, PF, Corr, Hole in side of LV Compt.
670	JB3-070			PF, Unknown contents/unsafe to lift
671	JB2-040			Loop, Corr, PF, Webs, Dirty, No Tags
672	JB2-050			Loop, No Tags, Dirty, PF, Corr
673	B6137 SE2			Corr, FDMU, Fuse diff sizes, Hole, Cut Wire, Dirty, Webs
674	T5130			Webs, Dirty, Weeds, 1-500

675	T4316A			PF, Dirty, Webs, Weeds
676	T4317B			Weeds, Dirty, Possible oil leak, No Load
677	B9109			Min Corr, Hole,
678	B-B3-L2-27			Dirty, Webs, No Load, Lights
679	B-B3-L2-41			Lights, Dirty,
680	B9128			Dirty, Old, NPS
681	B-LT27 SE2			Missing breaker blanks, NPS
682	B9142 SE2			NPS, missing all breaker blanks,
683	T-LT24			Dirty, Webs, Nest, Breaker not secure to LV compartment
684	B-B4-89 SE1			Dirty, Corr
685	T7108			Webs, Dirty, Weeds, Dirt
686	T7312			Maj Tilt, Dirty, Webs
687	B7218A SE2			Dirty, Grass clippings, Door found unsecured
688	T-LT7			Corr, PF, Dirty, Dirt
689	TC8			PF, Dirty, Dirt
690	TB2			PF, Shrubs, Dirty, Dirt
691	T1-53			Dirty, Webs
692	TB1			Dirty, Webs, Dirt, PF
693	B1			PF, Dirty, Locked
694	TB9			PF, Dirty, Webs, NT
695	T1-4			Dirty, Webs, Weeds, Dirt
696	T1-9			Dirty, Dirt
697	T1-8			Dirty, Dirt
698	T1-7			Dirty, Dirt
699	T1-5			Dirty, Weeds, Dirt
700	T1-10			Dirty, Weeds, Dirt
701	T95S1-3			Dirty, Webs, Possible oil Leak,
702	TB7			Dirty, Webs, Dirt, PF

703	T5224B			Live Front, Dirty, Webs,
704	JC5-010			Damaged
705	T5015			Severe Titl, Dirty
706	B8013 SE2			Missing KO, LNTW, Webs, Dirty
707	SB4-020			PF, Dirty, Webs, Nests, NT
708	T-RAMP1			Webs, Dirty Field Issue
709	T-RAMP9			Webs, Dirty, Live Front
710	T-RAMP11			Live Front, Web,s Dirty
711	T4127			Live Front, PF, Corr, Webs, Dirty
712	B4202 SE1C			Blocked by bushes
713	JB2-080			Could Not Open, lid jammed on left side
714	T5142			Webs, Dirty, Dirt, Corr
715	T4317A			Dirty
716	B9134			damaged cover,
717	T-LT25			Dirty, OOS, No secondary conductors
718	B9127			NPS
719	B9126			NPS, PF, Corr, missing breaker blanks,
720	B9125			NPS, PF, Corr
721	B9124			NPS, PF, Corr, Missing dead front,
722	B-LT28 SE2			Damaged, Broken Dead Front, Unsafe to open
723	B9122			Old, KO Hole uncovered, screw type fuses, Webs, Dirty
724	B9121B			Fire Pump controller, corr, can not open/rusted shut,
725	T9329			Major Titl, Dirty, Nests, Dirt
726	T7106B			PF, Corr, Dirty, Webs
727	T7318B			Dirty, Weeds, Dirt
728	T8215			Live Front, PF, Dirty
729	SW-37			Cut HV Cable, Missing HV Cover, Webs, Dirty,
730	BC5 SE1			PF, Dirty, Missing Breaker Blanks

731	BC11 SE2			Shrubs, Dirty, Min Corr, FDMU
732	SC-95S3			Door Issue, NT, Dirty, Webs, PF, HV Covers,
733	T5-7			PF, DSC On Cover, No Access
734	T5-8			PF, Bushes can not open
735	T1-1A			Titl, Cover blocked
736	B7108 SE2			Min Corr, Non-CE Padlock,
737	B95S2-5			PF Dirty, NPS, LockedNo Key,
738	T8015			Min Corr, Hole on side of LV Compartment
739	B5016 SE2			Dorr Damaged
740	B7238 SE2			Missing Breaker Blank
741	B4314			Lighting poor on new meeter
742	SW-35B			Dirty, Minor tilt
743	SC-35			Minor Tilt, Minor Webs
744	T11751C			Minor Titl, Dirty
745	B11751F			Min Corr, PF, Dirty
746	T11741			Min Corr, Dirty, Webs
747	M5112 CH			Chiller 1, Setting Display Inoperable,
748	T9112B			Corr, Dirty
749	T9112A			Dirty, LB Missing Cover
750	B9203 SE1			Meter Display Inoperable
751	T9220			Min Corr, Dirty, Rabbit habitat
752	B-LT9			Hole
753	B-LT10			Hole
754	T1-17			Tilt, PF, Min Corr
755	B -78			Missing Breaker Blanks, NPS,
756	T5270			Weeds, Dirt, Dirty, Tilt, Min Corr
757	SB2-010			PF, Corr, NT, HV Bushing Cover, D
758	TPB3-3			OOS, Loose Wires

759	B-FIRE2 SE2			Webbs, Pnl Bkr Blank & Door,
760	JB2-110			PF, Door Damage
761	B7230			Bkr blanks
762	SW-36B			Dirty, Webs, Tilt
763	B6125 SE2			Feeds B6126, Grass clippings, Min Corr, Door latch missing
764	T6138A			Hole, Dirty, Webs, No Load,
765	B-B4-8 SE1			Missing breaker blanks, NIS,
766	B8006 SE2			Missing Breaker Blank
767	T7008A			Major Tilt, Dirt
768	B4201			NPS, Missing Breaker Blanks
769	BC5-L1-6			Nest, KO Cover Missing, Fuses can't read, Cor, PF,
770	T11751B			Major Tilt, Webs, Dirty, Pad cracked
771	SW-95S			1-side can not open, NT,
772	T1-49			Bolt Damage, No Access
773	SC-95S1			Missing Bushing Covers, NT,
774	B7002			Exposed Bus, Missing Breaker Blanks
775	B7000A			Rusted, Water Present, Unsafe to Open,
776	B11751E			Door Hinge Broken
777	B11751B			NPS, Dirty, Door missing
778	JB3-060			Rusted shute, falling apart
779	B7116			No Dead Front
780	B7218A SE1			Missing Breaker Blanks, Exoposed Bus, Door Damaged (held with wire)
781	SC-5			Could Not Open
782	SW-1A			HV Covers Off, Dirty, Webs,
783	TR-84			Could not open
784	TR-83			Could Not Open
785	TR-79			Could not open
786	B8202A			Relay screen inoppperable, Corr

787	T1-14				Lid won't open
788	T1-25				Could Not Open
789	B95S2-6				1 of 2 bolts frozen, can not open,
790	BA10				Locked/No Key
791	B5020				Meter inoperable
792	SW-35				Major Tilt
793	T5204A				missing KO cover
794	T5016				Possible active oil leak (HV valve & LV XO Bushing), Webs, Dirty
795	BC4-L4-3				PF, Shrubs, Wasps, No Dead Front
796	B7402				Panel Disassebled, MLO, Dirty
797	JC2-240				Off Pad, Dirty
798	T7218A				Water logged, unsafe to Dranetz
799	B7339 SE2				FDMU and Differenct sizes: 2=100A, 1=80A
800	B6141 SE1				Can't open energized fuses
Studies & Training				Budget Represent s 6 Studies	
Year					
801	2025	Arc Flash Hazard Training			Provide NFPA 70E based arc flash hazard training to installation personnel
802	2025	Power Factor Study			To furthure investigate the reason for the sixty-four (64) transformers with a power factor below 90%, it is recommended to conduct a power factor study on each affected transformer
803	2025	Peak Load Study			To furthure investigate the three (3) tranformers that do not meet NEC 450.3, performing a Peak Load study on each transformer will allow for proper service entrance protection sizing.

804	2028	Power System Study five (5) year required update		
805	2025	Grounding study of Installation		An important aspect of any electrical system is the earth grounding. A study should be performed periodically for the following reasons: • Existing earth grounding system complies with original design. • Changes to the existing earth grounding system have been properly recorded. • The earth grounding system performs to design performance and/or acceptable standards.
806		Yearly preventative maintenance and testing		The electrical distribution system equipment should be periodically inspected and tested. This recommendation applies to all equipment included in this study.
TOTAL				

11.3 Electrical Equipment Maintenance

11.3.1 Selected Equipment

The electrical distribution system equipment should be periodically inspected and tested. This recommendation applies to all equipment included in this study. This includes the following types of equipment:

- Low voltage switchgear and circuit breakers.
- Protective relays.
- Switchboards
- Panelboards.
- Auxiliary equipment.

Periodic maintenance and testing are also a requirement in order to use the arc flash results provided in this report. An arc flash PPE level depends in part on the expected clearing time of an upstream protective device. Maintenance and testing are both necessary to ensure a device is functional and can be supported by an arc flash study. With respect to circuit breakers, maintenance confirms that the circuit breaker can operate as designed and testing confirms that a trip signal will be initiated as designed. NFPA 70E addresses this by requiring:

130.5(C)(B)b. The electrical equipment operating condition and condition of maintenance,

The condition of maintenance for a piece of equipment plays a major role in the safety of not only the maintenance employee but also the person operating the equipment. Improperly maintained or damaged equipment cannot be assumed to function normally or to provide the protection for the operator that would be afforded by proper installation and maintenance and recommended practices.

The term “condition of maintenance” refers to maintenance and testing of sufficient quality that the upstream protective device can be expected to operate as intended and within the analyzed operating time.

11.3.2 Maintenance Methods

NETA *Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems (MTS)* is recommended as a guide for the scope of maintenance.

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, or Air Force AFJMAN 32-1082, *Facilities Engineering Electrical Exterior Facilities*, can also be used as a maintenance reference. With respect to circuit breakers, refer also to the manufacturers’ instruction manuals for additional requirements.

11.3.3 Frequency of Electrical Equipment Maintenance

The frequency of inspection and testing varies with the equipment type. The following documents provide inspection and test frequency guidelines:

- NETA *Maintenance Testing Specifications for Electrical Power Distribution Equipment and Systems (MTS)*.
- NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*.
- Air Force AFJMAN 32-1082, *Facilities Engineering Electrical Exterior Facilities*.

AFJMAN 32-1082 recommends that existing medium voltage switchgear should have maintenance performed every 5 years.

12

DELIVERABLES

Section 12 summarizes the project's results and observations.

12.1 Deliverables

The following deliverables are provided as in support of this power system study:

- Analysis report summarizing project findings and results.
- Field walkdown data files – on DVD.
- EasyPower electrical model for the primary distribution system.
- Electronic copies of photographs taken of electrical equipment during field walkdowns – on DVDs.
- EasyPower software and associated training.
- Laptop computer capable of running the provided EasyPower software.
- New electrical distribution system single-line drawings.
- New electrical layout drawings.
- Arc Flash Hazard Labels.
- Required equipment identification Labels.
- Equipment Geospatial Data (ArcGIS model).

The following represent equipment with no identification labels.

Table 12-1 List of Equipment with no Identification Labels

Equipment ID
S&C #6
TPC4-L4-6
BC4-L4-6

Equipment ID
B8020
BC4-L4-3
GOAB B2-67
T8130A
T8130B
B8130B SE2
TP-TRAILER1
B-TRAILER1 SE1
B-TRAILER1 SE2
T8131
B8131 SE2
S&C #3
B8080B
B8080A
TP8014
B8014 SE1
B8015 SE1
B8015 SE2
B8015 SE1
Alpha Sub - SS
Bravo Sub - CB52SPP
Bravo Sub - CB 52U
Bravo Sub - Relays
Bravo Sub - Pri Sw
BS - B1 (ID "B1 Feeder 1")
BS - B2
BS - B3
BS - B4
T-Gen

Equipment ID
CS - Gen1
CS - Gen2
GOAB C4-17
T8040A
B8040A SE1
B8040A SE2
T8040B
B8040B SE1A
B8040B SE1B
B8040B SE2
B8046 SE1
B8046 SE2
TP8037
B5204B
B5204A SE1
B5204A SE2
B5270 SE1
B5270 SE2
B5205
T5209
B5225 SE1
B5225 SE2
SC5-010
TPC5-17
BC5-17 SE1
TP5305
TPC5-27A
BC5-17 SE2
JC5-010

Equipment ID
FSW-CASS1
B-CASS1
B5262
FSW-CASS2
B-CASS2
B5280
TP5206
B5206
TPC4-L6-3
TP52308 (TP5208)
B5115 SE1
B5201 SE2
B5016 SE2
BC4-L9-1
T8031
GOAB B2-24
CAP B2-19
TPB2-9
B-TB2-9 se1
TP9018
B-TP9018 SE1
T9018
B9018 SE2
B-TP9018 SE2
GOAB B1-25
TPB1-34
B-TPB1-34
CAP B1-37
BLADES B1-38

Equipment ID
GOAB B1-39
TPB1-40
B-TPB1-40
TP6015
B6015 SE1
S&C #1
GOAB C4-57
CAP C4-47
TP5000
B5000
GOAB C4-40
JC4-030
CAP-C4-27
GOAB C4-19
BC3-18B
BC3-18A
T9320
B9320
TPB3-8
TP-TRAILER2
B-B3-8
B-TRAILER2
TPB4-8
B-B4-8 SE1
B-B4-8 SE2
TP9104
B9105
B-TP9104 SE1
B-TP9104 SE2

Equipment ID
B-TP9104 SE3
GOAB B2-L1-1
BLADES B2-L1-3
GOAB B2-L1-7
TPB1-L3-1
TP4095
B4095
TPB1-L3-11
T9024
B9024
JB1-040
B3-L1-8
B-FIRE1
B-FIRE2 SE1
B-FIRE2 SE2
JB3-010
GOAB B3-26
S&C #2
CAP C2-42
JB3-020
TP6221
GOAB C2-35
JC2-010
GOAB B2-L3-4
JB2-110
TP-B2-L2-2
JB2-100
T-LT1
B-LT1

Equipment ID
GOAB B2-L2-5
TPC4-L15-2
C4-L14-2
TPC4-L13-1A
TP4310
B4310
TPC4-L10-2
JC4-010
B2-53
T8011
B8011 SE3
B8011 SE1
B8008
T8006
B8006 SE1
B8006 SE2
T8013
B8013 SE1
B8013 SE2
B8013 SE3
B8013 SE4
T8001
B8001 SE2
B8001 SE1
T7008C
JB2-320
T7008D
B70008D SE1
B7008D SE2

Equipment ID
B7008D SE3
T7008A
B7008B
M7008A
M7008B
B7007A SE2
B7010 SE1
B7010 SE2
B7010 SE3
T-BALL1
B-BALL1
B7238 SE1
B7238 SE2
T7237
B7237 SE1
B7237 SE2
B7237 SE3
JB2-200
JB2-210
B7234
B7233 SE1A
B7233 SE2
B7233 SE2
T7230
B7230
T8031
T5013
B5003A SE1B
B5003A SE1A

Equipment ID
B5003A SE2
B5003B
B5004A
B5020
T5001
B5001
B7040
T7002
B7002
T7004D
B7004C SE2
B7004C SE1
B7004B
MTR7004B
MTR7004C
B7000B
MTR7000B
MTR7000A
B7000A
B7000A SE2
M7000A CH
B7101
JC2-220
G-C2-L1-24
C2-L1-25
SB4-020
T-SB4-010B
B-SB4-010B
T-SB4-010A

Equipment ID
B-SB4-010A
B11990
T-36A
B-36A SE1
B-36A SE2
SW-35B
B-89
T-43A
B-43A SE1
B-43A SE2
B-86
B-87
B-25A SE1
B-25A SE2
B-25A SE3
B-RAMP1
B-RAMP2
B-RAMP3 SE1
B-RAMP3 SE2
T-RAMP15
B-RAMP16
SC4-010
B-RAMP25 SE2
T-RAMP28
B-RAMP28
B9001
T4101
T4127
B4170B

Equipment ID
T4316B
B4112
B4222
B4202 SE1A
B4225 SE2
T11751E
T11751A
B11751A
TPC5-L1-6
T11751B
B11751B
T11751D
B11751D
T11751C
B11751C
T11751F
B11751F
T11741
TPC-5-15
B-LIFT1
TP8119
TP8120
SC-6112B
T6113
B6113 SE1
B6113 SE2
T6115
B6115
B6117

Equipment ID
T6119
B6119
SB3-015
T6123
B6123
B6122A
B6122B
T6125B
SC-6125A
B6125 SE2
B6125 SE1
B6125 SE3
T6127A
B6127A
B6127B
B6132
JB2-028
B6136B SE1
B6136B SE2
B6136A SE1
B6136A SE2
B6130
B6137 SE1
B6137 SE2
B6138A
B6138B SE2
B6138B SE1
JB2-080
B6141 SE2

Equipment ID
B6141 SE1
T6142
B5130
T5112
T5142
B5142 SE1
B5142 SE2
B5110A SE1
T5110B
B5110B SE1
B5110B SE2
B5110B SE3
B5110B SE4
B5110B SE5
B5110B SE6
T5160B
T5109
T5108
T5108B
B5108B SE2
B5108B SE1
B5108B SE1
T4315
B4317A SE1A
T4218
b4218 se1
b4218 se2
b4218 se3
BP4218 SE1

Equipment ID
BP4218 SE2
T9109
B9109
B9109
B910 B9110 SE1
B9110 SE2
T9350
B9350 SE1
B9350 SE2
T-LT31
B-LT31
TPB3-L2-27
B-B3-L2-27
TPB3-L2-28
B9135
B9134
B9133
TPB3-L2-40
B9132
B-B3-L2-41
B9131
B9130
B9129
B9128
B9127
B-LT27 SE1
B-LT27 SE2
B9126
B9125

Equipment ID
B9124
T-LT28
B-LT28 SE1
B-LT28 SE2
B9122
B-LT29 SE1
B-LT29 SE2
B9118
B-LT22 SE1
B-LT22 SE2
T9165
T9169
T-LT23
B-LT23 SE1
B-LT23 SE2
T9142
B9142 SE2
T-LT24
B-LT24
B9139
MR9138
MR9173
MR9170
MR9167
MR9164
B9045 SE1
B9045 SE2
B9045 SE3
B9045 SE4

Equipment ID
B9045 SE2A
B9045 SE2B
B9045 SE4A
B9121A SE2
B9121A SE1
B9121B
T-BOMBPAD
B-BOMBPAD
B9121A SE2
TPB4-L2-1
B-B4-L2-1
B-LIFT2 SE1
B-LIFT2 SE3
B4-67
T9243
B9199
B4-73
T9201
B9201
B9203 SE2
T9222
B9222
T9219
B9219 SE1
B9220 SE1
T9220
B9220 SE2
B9220 SE1
B-B4-83 SE1

Equipment ID
B-B4-83 SE2
B-LT2
B-B4-89 SE1
B-B4-89 SE2
B-LT3
T-LT12
B-LT12
T9097
SC-9096
T9330
B9330 SE1
TP9104 SE3
TP9104 SE2
B9190 SE1
B9190 SE1A
B9190 (Panel A)
B9198 SE2
T9304
B9304
T9305
B9329 SE1
B9329 SE3
B-C2-7
B7301 SE2
B7115
JC2-040
B7116
JC2-030
T7110

Equipment ID
B7110
B7108 SE1
B7108 SE2
T7106B
B7106B SE1
B7106B SE1
B7106B SE2
B7106A
B7106A
B6220
JC2-260
B6222
JC2-250
B7402
JC2-240
B7403
T7421
T7405
B7405 SE1
B7405 SE2
B7407 SE2
B7407 SE1
T7413
SC2-010
T7409
B7409 SE2
B7409 SE1
B7340 SE2
B7339 SE4

Equipment ID
JC2-230
B7312 SE2
B7312 SE1
JC2-070
JC2-060
B7216
T7215
B7215
B7217
T7223
M7223 CH1
M7223 CH2
JC2-130
B7218A SE1
B7218A SE2
B7219A
T7220A
B7220A
JC2-150
JC2-180
JC2-190
B7316A SE1
B7316A SE2
B7316B
JC2-200
T7416
JC2-210
B-C2-L1-22
T7206

Equipment ID
B7206 SE1
B7206 SE2
JC2-080
JC2-090
T7320
T7318A
SC2-020
JC2-170
JC2-160
T6030B
T6030A
B7104
B7117
JB2-310
JB2-120
JB2-130
JB2-220
JB2-230
JB2-250
JB2-260
B-LT1
B-C1-4 SE1
B4-94
BR-109
PA2-A1
SC-39
B11905
BA2-L2-5 SE1
BA2-L2-5 SE2

Equipment ID
B-LT6
B-LT7
B-LT8
B-LT9
T-LT10
B-LT10
T-LT11
B-LT11
T11955A
B11955A SE2
B11955B
T11959
B11959
B11955A SE4
SC-95S
SW-95S
B1-24 SE7
T1-17
T-40A
B-40A SE1
B-40A SE1A
SW-1A
SC-1A
SC-1D
SC-1c
SC-1E
T1-1A
B-1A SE1
B-1A SE2

Equipment ID
SC-1B
TC5
BC5 SE2
BC5 SE1
TC6
BC6
TC8
BC8
TC7
BC7 SE2
BC7 SE1
TC9
BC9
TC10
BC10
TC11
BC11 SE2
BC11 SE1
TB3
BB3
TB2
BB2
TC2
BC2
TC3
BC3
TC1
BC1
SC-95S4

Equipment ID
TC4
BC4
B-71
B-70
B-69
B-67
B-66
B-64
TR-63
B-63
B-62
B-61
B-83
B-59 SE2
B-59 SE1
B-73
B-74
B-75
B-77
B-79
B-57
T14402
B14402
B-80
B-81
B-82
SC-95S1
T95S1-1
B95S1-1

Equipment ID
SC-95S1A
SW-05S
SC-95S3
TB1
B1
T5-7
T5-6
B5-6 SE1
T5-3
T5-2
TB9
BB9
T5-1
T5-4
T5-5
T5-8
T95S1-2
B95S1-2
T95S1-3
B95S1-3
T95S2-6
B95S2-6
TB8
BB8
TB5
BB5
BB5 SE2
TB4
BB4

Equipment ID
TB6
BB6
TB7
BB7
T95S2-4
B95S2-4
T95S2-5
B95S2-5
T95S2-3
B95S2-3
TA10
BA10
T95S2-2
B95S2-2
B9265 SE1
B9265 SE2
T-LT4
B-LT4
T-GENA (T-BESS-N)
T-GENB (T-EG1)
T-GENC
B-GEN S1
B-GEN CTRL
SWGR 1
SWGR 2
SWGR 3
SWGR 4
SWGR 5
SWGR 6

Equipment ID
SWGR 7
SWGR 8

13

REFERENCES

13.1 Military Criteria

1. AFI 32-1062, *Electric Power Plants and Generators*.
2. AFI 32-1063, *Electric Power Systems*.
3. ETL 09-10, *Aurora Electrical System Vulnerability Assessment and Mitigation Actions*.
4. ETL 09-11: *Civil Engineering Industrial Control System Information Assurance Compliance*.
5. UFC 3-501-01, Change 1, *Electrical Engineering*.
6. UFC 3-520-01, Change 2, *Interior Electrical Systems*.
7. UFC 3-550-01, Change 1, *Exterior Electrical Power Distribution*.
8. UFC 3-560-01 Change 4, *Electrical Safety, O&M*.

13.2 Industry Standards

1. ANSI/IEEE C37.13-1990™, *IEEE Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures*.
2. ASTM D877 – 1995, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
3. ASTM D924 – 2016, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant).
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Volume 2 Appendix List (Note: Only Used for References)

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Appendix C Energized Work Summary Table

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