

October 3, 2017

Arc Flash Study

Prepared for:

ABC

City, State

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CONTENTS

Arc Flash Study Overview

Incident Energy Summary Report

Equipment Evaluation Report

PPE Poster

Arc Flash Model Drawing

October 3, 2017

ABC – City, State – Arc Flash Study

Thank you for the opportunity to provide this Arc Flash Study of the electrical distribution system for the XYZ in city, state.

The current version (v7.0) of SKM Power Tools Arc Flash modeling, equipment evaluation, short circuit current analysis and over current device coordination software programs were used to determine Arc Flash incident energy levels for this project. IEEE Standard 1584 modeling software and NFPA 70E 2015 edition was used for verification.

The results of the calculations and models have been documented on four (4) drawings based on the facility distribution system. The calculations have been based on data collected during my on-site visit on October 1-3, 2017. Having the assistance of Bryan Johnson and Jason Bateman facilitated the data collection greatly.

The results contained in this report are based on the design and information available at the time this report was completed. Any changes made to equipment settings or system configuration will invalidate the results contained in this report and may result in a more hazardous condition thus, necessitating a follow-up review of this arc flash study.

The Incident Energy Summary Report and Equipment Evaluation Report provide the detailed results however; the six (6) highlights of this Arc Flash Study are summarized as follows:

1) Utility Fault Current Contribution

The short circuit fault current available at the primary incoming bus for the incoming utility service to the xyz in city was made available.

2) 13.8kV and 480V Switchgear, and Generator Buses @ DANGEROUS Level

Operation of the disconnect devices on the 13.8kV Switchgear in all four units is indicated as DANGEROUS (>40 calories/cm²). This is not unusual for a protective device fed from a large generator, or protective devices located on the secondary of transformers fed from a utility, or at the incoming main lugs of a power distribution center as the transformer significantly increases the response time of the upstream protective device.

Operation of all the protective devices connected to the 480V Switchgear in three of the four units is indicated as DANGEROUS (>40 calories/cm²). Operation of protective devices connected to SWGR 412 is indicated as 37 calories/cm² or PPE Level 4. This is due to different, faster response relay settings on SWGR 412 Relay than the other 480V switchgear relays.

Operation of the Generator Circuit Breakers on all four units is indicated as DANGEROUS (>40 calories/cm²).

These DANGEROUS levels may be mitigated by increasing the working distance to enable the use of AF PPE Level 4. See the notes on the arc flash model drawing for details. Handle extensions may be available to achieve this increased working distance. Remote operation of the switches or circuit breakers may also be an option to consider.

3) **System Mis-coordination**

The Incident Energy Summary Report indicates a few areas of over current device mis-coordination, see the (*N5) notations in the arc flash summary report. In a few cases, subpanel branch breakers are coordinated to the bus duct fused disconnects bypassing the subpanel main breakers.

In an industrial power system, mis-coordination is not an uncommon situation to find and it typically works in your favor relative to arc flash as the speed of the upstream protective device reduces the incident energy exposure. These upstream protective devices function in this manner only in an overload condition. As we understand the system is reliable and functions well, our recommendation is to leave these devices and their settings in their current state. While a detailed system analysis could be considered, it should be noted that this power system device coordination analysis could consume significant engineering and field monitoring cost.

4) **Equipment Evaluation Report**

The Equipment Evaluation Report indicates a few failures or marginal ratings. These are primarily in two areas of over current device ratings in the Device Evaluation Summary Reports. One area is the Short Circuit Current Available ratings for a device > 80% SCCA ratings and the other is related to connected load to the device > 80% for continuous load ratings.

- a. In the case of the available short circuit current ratings, these devices are continuous duty rated and thus they are suitable for the service as designed and intended. This is a software default value based on the NEC and in this case is not applicable to your system.
- b. The second area is relative to connected load greater than 80% and 100%. The software cannot determine the real horsepower of a particular motor and assumes it to be 100% loaded. It cannot determine true loading of multiple motors operated in a lead / lag configuration. It calculates to 100% load on every device connected. It cannot calculate diversity of loads per the NEC. This is the only reason you will find a marginal rating on a device due to loading > 80% or a failure rating on a device due to loading > 100%.

5) **Equipment Labeling**

The switchboard and motor control center (MCC) sections will be labeled to the actual incident energy levels per the requirements of IEEE 1584 and NFPA 70E for testing, troubleshooting and interacting with the device with exposed energized parts. All disconnects that could require maintenance, testing or troubleshooting will be labeled to the requirements of NFPA 70E 130.5(D); extracted text from provided next.

NFPA 70E, 2015 Edition (Pg. 28)

130.5 (D) Equipment Labeling. Electrical equipment such as switchboards, panel boards, industrial control

panels, meter socket enclosures, and motor control centers that are in other than dwelling units and that are likely to require examination, adjustment, servicing, or maintenance while energized shall be field-marked with a label containing all the following information:

- (1) Nominal system voltage
- (2) Arc flash boundary
- (3) At least one of the following:
 - a. Available incident energy and the corresponding working distance, or the arc flash PPE category in Table 130.7(C)(15)(A)(b) or Table 130.7(C)(15)(B) for the equipment, but not both
 - b. Minimum arc rating of clothing
 - c. Site-specific level of PPE

Exception: Labels applied prior to September 30, 2011 are acceptable if they contain the available incident energy or required level of PPE.

The method of calculating and the data to support the information for the label shall be documented. Where the review of the arc flash hazard risk assessment identifies a change that renders the label inaccurate, the label shall be updated.

The owner of the electrical equipment shall be responsible for the documentation, installation, and maintenance of the field-marked label.

6. Operation of Electrical Equipment

The motor control centers and distribution panels are typical lockout points. The calculated energy levels as indicated on the drawings are often in excess of 1.2 calories/cm² and as such would require some level of arc rated PPE. The extracted text from NFPA 70E 2015 edition regarding this situation is provided next.

NFPA 70E, 2015 Edition (Pg. 24)

130.2 Electrically Safe Working Conditions

(A) Energized Work

(4) Normal Operation. Normal operation of electric equipment shall be permitted where all of the following conditions are satisfied:

- (1) The equipment is properly installed.
- (2) The equipment is properly maintained.
- (3) The equipment doors are closed and secured.
- (4) All equipment covers are in place and secured.
- (5) There is no evidence of impending failure.

Informational Note: *The phrase properly installed means that the equipment is installed in accordance with applicable industry codes and standards and the manufacturer's recommendations. The phrase properly maintained means that the equipment has been maintained in accordance with the manufacturer's recommendations and applicable industry codes and standards. The phrase evidence of impending failure means that there is evidence such as arcing, overheating, loose or bound equipment parts, visible damage, or deterioration.*

Task	Equipment Condition*	Arc Flash PPE Required
... Voltage testing on individual battery cells or individual multi-cell units or Removal of battery inter-cell connector covers	All of the following: The equipment is properly installed The equipment is properly maintained All equipment covers are in place and secured There is no evidence of impending failure	No
	One or more of the following: The equipment is not properly installed the equipment is not properly maintained Equipment doors are open or not secured Equipment covers are off or not secured There is evidence of impending failure	Yes

NFPA 70E makes it very clear the determination of this condition can only be made by the responsible person in charge of the facility. If the facility has evidence and documentation as per the requirements of NFPA 70E 205.3, 205.4 and 210.5 that all five conditions are met, then no arc rated PPE would be required to operate disconnects with the doors properly closed and latched. **"In our experience, it is very rare that equipment is maintained to the exact specifications of the manufacturer"**. For reference see NFPA extracts listed below.

A safer approach could be taken. Other facilities with similar situations provide an appropriate Arc Rated switchers coat, face shield and leather gloves in each of the MCC rooms and then instruct the task qualified workers when performing the lock out procedure to wear the coat, hard hat, face shield and gloves to interact with the disconnect in question. If this approach is taken, the under-layer clothing shall be 100% natural fiber non-melting clothing per NFPA 70E. After the disconnect switch is operated to the "off" position, then lock out procedures can be performed without any arc rated PPE.

NFPA 70E, 2015 Edition (Pg. 44 & 45)

205.3 General Maintenance Requirements. Electrical equipment shall be maintained in accordance with manufacturers' instructions or industry consensus standards to reduce the risk associated with failure. The equipment owner or the owner's designated representative shall be responsible for maintenance of the electrical equipment and documentation.

Informational Note: *Common industry practice is to apply test or calibration decals to equipment to indicate the test or calibration date and overall condition of equipment that has been tested and maintained in the field. These decals provide the employee immediate indication of last maintenance date and if the tested device or system was found acceptable on the date of test. This local information can assist the employee in the assessment of overall electrical equipment maintenance status.*

205.4 Overcurrent Protective Devices. Overcurrent protective devices shall be maintained in accordance with the manufacturers' instructions or industry consensus standards. Maintenance, tests, and inspections shall be documented.

210.5 Protective Devices. Protective devices shall be maintained to adequately withstand or interrupt available fault current.

Informational Note: *Improper or inadequate maintenance can result in increased opening time of the overcurrent protective device, thus increasing the incident energy.*

The calculations in this study and resultant incident energy levels are based upon the overcurrent devices (overcurrent relays, circuit breakers, and fused disconnects) operating as designed and being properly maintained. Maintenance intervals should be based on the manufacturer's recommendations or industry consensus testing standards. This is typically a 3 to 5-year interval based on the conditions of the equipment. The InterNational Electrical Testing Association (NETA) provides guidance documents for adjusting these intervals based on location conditions.

It is important to note that in many cases, changing the trip settings of the equipment in place in the facility is relatively simple to do. Full-function circuit breakers and time overcurrent relay devices often have adjustable long-time, short-time and instantaneous (LSI) trip units that provide the unique ability to modify or change the trip settings with a small screwdriver. As any changes to the equipment settings may have a significant impact on the incident energy levels found in the electrical system, the facility should have a change management process in place to maintain the settings as found for this Arc Flash Study. Any change to the site distribution system or a change by the utility relative to your incoming service fault current could necessitate a review of this arc flash study.

Annex H of NFPA 70E provides guidance for a clothing system to 12 calories/cm² and as such on all the model drawings anytime there is a PPE Category 3 situation it will be indicated as such with the specific calories/cm² exposure. This can help you if your clothing supplier is providing 12 calories/cm² clothing. This needs to be verified to what level of protection your PPE uniform clothing provides. This can be your decision after verification of the ATPV of the clothing supplied, documented and communicated to the affected personnel.

Layering of Arc rated clothing is allowed as long as it has been tested as a system. This information is available on the clothing manufacturers' websites as well as on ArcWear.com. As an example, Westex has tested their Indura Ultrasoft shirt with their T-shirt (typical rental company provided material) and the combination achieves 20 calories/cm². Tyndale's 9 calories/cm² shirt has been tested with various other 4 calories/cm² T-shirts achieving slightly higher overall results when used together.

Any exposures greater than PPE Category 1 (> 4 calories/cm²) requires the use of an arc rated face shield and balaclava or an arc rated face shield hood assembly.

NFPA 70E requires the arc flash study to be reviewed every five years. If the utility contacts you for a service interruption, ask the question for what purpose. If they are upgrading the transmission line or transmission / distribution transformers, this is your indication to find out what the change will be to your incoming fault current and relay clearing times which can affect the arc flash calculations.

If the utility has not changed anything relative to your incoming service fault current and you have not changed anything in your distribution system on site, then the review can be a very simple process of noting this fact every 5 years. A verification from the utility of the utility information found on the arc flash study document and also contained on the USB drive is all that would be required.

Equipment Evaluation Report. All of the relative files in PDF, native Microsoft Office format and native SKM format are provided on an USB drive for file retention. It is recommended that these files be retained in a secure location within your organization. e-Hazard also retains the files backed up to a "secured cloud service".

I keep an exact duplicate of the documentation binder in my office so if there is ever a question, we can both look at the exact same piece of information at any time in the future. If I should be traveling, I have all the files on my laptop with me.

Please call John Aeiker, 251-581-1492 for any additional clarification relative to this report.
Thank you,



john.aeiker@e-hazard.com

SAMPLE

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective	Bus	Bus	Bus	Prot Dev	Prot Dev	Trip/	Breaker	Ground	Equip	Gap	Arc	Working	Incident	PPE Level
2		Device	kV	Bolted	Arcing	Bolted	Arcing	Delay	Opening		Type	(mm)	Flash	Distance	Energy	
3		Name		Fault	Fault	Fault	Fault	Time	Time/Tol				Boundary	(in)	(cal/cm2)	
4				(kA)	(kA)	(kA)	(kA)	(sec.)	(sec.)				(in)			
5	13.8kV Bus - SWGR 11	MaxTripTime @2.0s	13.80	26.20	25.01	24.82	23.72	2	0.000	Yes	SWG	153	2299	36	68	Dangerous! (*N2) (*N9)
6	13.8kV Bus - SWGR 21	MaxTripTime @2.0s	13.80	25.72	24.56	25.32	24.18	2	0.000	Yes	SWG	153	2252	36	67	Dangerous! (*N2) (*N9)
7	13.8kV Bus - SWGR 31	MaxTripTime @2.0s	13.80	26.12	24.94	24.74	23.64	2	0.000	Yes	SWG	153	2292	36	68	Dangerous! (*N2) (*N9)
8	13.8kV Bus - SWGR 41	MaxTripTime @2.0s	13.80	25.72	24.56	25.32	24.18	2	0.000	Yes	SWG	153	2252	36	67	Dangerous! (*N2) (*N9)
9	Black Start Gen Connection Pt	SWGR 312 - MCC 3121 CB	0.48	67.57	33.54	31.25	15.51	0.3	0.000	Yes	PNL	25	138	18	34	Level 4 (*N21)
10	Black Start Generator Bus	MaxTripTime @2.0s	0.48	6.68	4.65	6.68	4.65	2	0.000	Yes	PNL	25	126	18	29	Level 4 (*N2) (*N9)
11	Chiller Heater 1 Cabinet	XFMR - Chiller Heater 1 Relay	0.48	17.04	10.34	17.04	10.34	1	0.083	Yes	PNL	25	145	18	37	Level 4
12	Chiller Heater 2 Cabinet	XFMR - Chiller Heater 2 Relay	0.48	17.23	10.44	17.23	10.44	1	0.083	Yes	PNL	25	146	18	37	Level 4
13	Chiller Heater 3 Cabinet	XFMR - Chiller Heater 3 Relay	0.48	17.05	10.34	17.05	10.34	1	0.083	Yes	PNL	25	145	18	37	Level 4
14	Chiller Heater 4 Cabinet	XFMR - Chiller Heater 4 Relay	0.48	16.90	10.27	16.90	10.27	1	0.083	Yes	PNL	25	144	18	36	Level 4
15	CT Pump 1 Bus	SWGR 111 52-CT	4.16	10.54	10.22	10.39	10.07	0.004	0.000	Yes	SWG	104	1	36	0.05	Level 0
16	CT Pump 2 Bus	SWGR 211 52-CT	4.16	10.50	10.18	10.34	10.03	0.004	0.000	Yes	SWG	104	1	36	0.05	Level 0
17	CT Pump 3 Bus	SWGR 311 52-CT	4.16	10.57	10.25	10.41	10.09	0.004	0.000	Yes	SWG	104	1	36	0.05	Level 0
18	CT Pump 4 Bus	SWGR 411 52-CT	4.16	10.46	10.15	10.31	10.00	0.004	0.000	Yes	SWG	104	1	36	0.05	Level 0
19	Generator Bus Unit 1	MaxTripTime @2.0s	13.80	19.30	18.53	19.30	18.53	2	0.000	Yes	SWG	153	1674	36	50	Dangerous! (*N2) (*N9)
20	Generator Bus Unit 2	MaxTripTime @2.0s	13.80	19.30	18.53	19.30	18.53	2	0.000	Yes	SWG	153	1674	36	50	Dangerous! (*N2) (*N9)
21	Generator Bus Unit 3	MaxTripTime @2.0s	13.80	19.30	18.53	19.30	18.53	2	0.000	Yes	SWG	153	1674	36	50	Dangerous! (*N2) (*N9)
22	Generator Bus Unit 4	MaxTripTime @2.0s	13.80	19.30	18.53	19.30	18.53	2	0.000	Yes	SWG	153	1674	36	50	Dangerous! (*N2) (*N9)
23	LP1121 Main	MCC 1121 LP1121 CB	0.208	2.60	1.69	2.60	1.69	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
24	LP2121 Main	MCC 2121 LP2121 CB	0.208	2.55	1.67	2.55	1.67	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
25	LP3121 Main	MCC 3121 LP3121 CB	0.208	2.60	1.69	2.60	1.69	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
26	LP4121 Main	MCC 4121 LP4121 CB	0.208	2.55	1.67	2.55	1.67	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
27	MCC 1121 Bus	SWGR 312 - MCC 3121 CB	0.48	48.63	25.33	22.16	11.54	0.3	0.000	Yes	PNL	25	115	18	25	Level 4 (*N21)
28	MCC 1121 Typ 100A Load	MCC 1121 Typ 100A CB	0.48	11.39	7.33	11.27	7.25	0.025	0.000	Yes	PNL	25	12	18	0.59	Level 0
29	MCC 1121 Typ 200A Load	MCC 1121 Typ 200A CB	0.48	21.66	12.69	20.90	12.25	0.025	0.000	Yes	PNL	25	17	18	1.1	Level 0

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective	Bus	Bus	Bus	Prot Dev	Prot Dev	Trip/	Breaker	Ground	Equip	Gap	Arc	Working	Incident	PPE Level
2		Device	kV	Bolted	Arcing	Bolted	Arcing	Delay	Opening		Type	(mm)	Flash	Distance	Energy	
3		Name		Fault	Fault	Fault	Fault	Time	Time/Tol				Boundary	(in)	(cal/cm2)	
4				(kA)	(kA)	(kA)	(kA)	(sec.)	(sec.)				(in)			
30	MCC 1121 Typ 400A Load	MCC 1121 Typ 400A CB	0.48	30.58	17.04	29.29	16.32	0.025	0.000	Yes	PNL	25	20	18	1.5	Level 1
31	MCC 1121A Bus	MCC 1121A Main CB	0.48	13.13	8.27	13.13	8.27	0.011	0.000	Yes	PNL	25	8	18	0.31	Level 0
32	MCC 1121A Main @ Demin H2O	MCC 1121 - MCC 1121A CB	0.48	13.25	8.34	13.25	8.34	0.025	0.000	Yes	PNL	25	13	18	0.68	Level 0
33	MCC 1122 Bus	MCC 1122 Main CB	0.48	17.27	10.46	16.55	10.02	0.053	0.000	Yes	PNL	25	23	18	1.8	Level 1
34	MCC 1122 LPCT Main	MCC 1122 LPCT CB	0.208	0.78	0.73	0.78	0.73	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
35	MCC 1122 Main @ CT Bldg	SWGR 112 - MCC 1122 CB	0.48	17.42	10.54	16.70	10.10	0.172	0.000	Yes	PNL	25	47	18	5.8	Level 2 (*N21)
36	MCC 1122 Typ CT Drive	MCC 1122 Typ CT Drive CB	0.48	3.07	2.39	3.05	2.37	0.015	0.000	Yes	PNL	25	4	18	0.11	Level 0
37	MCC 1122 Typ CT Fan	MCC 1122 Typ CT Fan CB	0.48	10.88	7.05	10.30	6.67	0.015	0.000	Yes	PNL	25	8	18	0.34	Level 0
38	MCC 1223 LP 12A & 12S Mains	MCC 1223 LP12A & 12S CB	0.208	1.97	1.39	1.97	1.39	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
39	MCC 1223 LP12A & 12S XFR SW	MCC 1223 LP12A & 12S CB	0.48	37.97	20.50	37.97	20.50	0.01	0.000	Yes	PNL	25	13	18	0.72	Level 0
40	MCC 1223 MLO Bus	SWGR 112 - MCC 1223 CB	0.48	41.71	22.21	40.78	21.72	0.05	0.000	Yes	PNL	25	37	18	3.9	Level 1 (*N21)
41	MCC 1223 Typ CW Pump	MCC 1223 Typ CW Pump CB	0.48	22.81	13.26	22.10	12.85	0.01	0.000	Yes	PNL	25	10	18	0.47	Level 0
42	MCC 1223 Typ Drive/Heater	MCC 1223 Typ Drive CB	0.48	3.30	2.55	3.28	2.53	0.015	0.000	Yes	PNL	25	4	18	0.11	Level 0
43	MCC 2121 Bus	SWGR 212 - MCC 2121 CB	0.48	27.32	15.47	24.85	14.08	0.172	0.000	Yes	PNL	25	61	18	8.8	Level 3
44	MCC 2121 Typ 100A Load	MCC 2121 Typ 100A CB	0.48	10.20	6.67	10.06	6.58	0.025	0.000	Yes	PNL	25	11	18	0.54	Level 0
45	MCC 2121 Typ 200A Load	MCC 2121 Typ 200A CB	0.48	16.59	10.11	15.78	9.61	0.025	0.000	Yes	PNL	25	15	18	0.84	Level 0
46	MCC 2121 Typ 400A Load	MCC 2121 Typ 400A CB	0.48	21.02	12.37	19.67	11.57	0.025	0.000	Yes	PNL	25	17	18	1.0	Level 0
47	MCC 3121 Bus	SWGR 312 - MCC 3121 CB	0.48	56.58	28.82	25.97	13.23	0.3	0.000	Yes	PNL	25	125	18	29	Level 4 (*N21)
48	MCC 3121 Typ 100A Load	MCC 3121 Typ 100A CB	0.48	11.72	7.51	11.60	7.44	0.025	0.000	Yes	PNL	25	12	18	0.61	Level 0
49	MCC 3121 Typ 200A Load	MCC 3121 Typ 200A CB	0.48	23.10	13.41	22.34	12.97	0.025	0.000	Yes	PNL	25	17	18	1.1	Level 0
50	MCC 3121 Typ 400A Load	MCC 3121 Typ 400A CB	0.48	33.57	18.45	32.29	17.75	0.025	0.000	Yes	PNL	25	22	18	1.6	Level 1
51	MCC 3121A Bus	MCC 3121A Main CB	0.48	7.50	5.13	7.50	5.13	0.014	0.000	Yes	PNL	25	7	18	0.23	Level 0
52	MCC 3121A Main @ Demin H2O	MCC 3121 - MCC 3121A CB	0.48	7.54	5.15	7.54	5.15	0.025	0.000	Yes	PNL	25	9	18	0.41	Level 0
53	MCC 3122 Bus	MCC 3122 Main CB	0.48	50.35	26.09	49.59	25.69	0.05	0.000	Yes	PNL	25	41	18	4.7	Level 2
54	MCC 3122 Chem Bldg LP Main	MCC 3122 Chem Bldg LP CB	0.208	3.40	2.04	3.40	2.04	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective	Bus	Bus	Bus	Prot Dev	Prot Dev	Trip/	Breaker	Ground	Equip	Gap	Arc	Working	Incident	PPE Level
2		Device	kV	Bolted	Arcing	Bolted	Arcing	Delay	Opening		Type	(mm)	Flash	Distance	Energy	
3		Name		Fault	Fault	Fault	Fault	Time	Time/Tol				Boundary	(in)	(cal/cm2)	
4				(kA)	(kA)	(kA)	(kA)	(sec.)	(sec.)				(in)			
55	MCC 3122 Main @ CT Bldg	SWGR 312 - MCC 3122 CB	0.48	51.58	26.63	50.82	26.24	0.05	0.000	Yes	PNL	25	42	18	4.8	Level 2 (*N21)
56	MCC 3122 Typ CT Drive	MCC 3122 Typ CT Drive CB	0.48	3.33	2.56	3.31	2.55	0.015	0.000	Yes	PNL	25	4	18	0.11	Level 0
57	MCC 3122 Typ CT Fan	MCC 3122 Typ CT Fan CB	0.48	17.94	10.80	17.41	10.48	0.015	0.000	Yes	PNL	25	11	18	0.54	Level 0
58	MCC 3423 LP34A & 34S Mains	MCC 3423 LP34A & 34S CB	0.208	1.97	1.39	1.97	1.39	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
59	MCC 3423 LP34A & 34S XFR SW	MCC 3423 LP34A & 34S CB	0.48	37.97	20.50	37.97	20.50	0.01	0.000	Yes	PNL	25	13	18	0.72	Level 0
60	MCC 3423 MLO Bus	SWGR 312 - MCC 3423 CB	0.48	41.70	22.21	40.78	21.72	0.05	0.000	Yes	PNL	25	37	18	3.9	Level 1 (*N21)
61	MCC 3423 Typ CW Pump	MCC 3423 Typ CW Pump CB	0.48	22.81	13.26	22.10	12.85	0.01	0.000	Yes	PNL	25	10	18	0.47	Level 0
62	MCC 3423 Typ Drive/Heater	MCC 3423 Typ Drive CB	0.48	3.30	2.55	3.28	2.53	0.015	0.000	Yes	PNL	25	4	18	0.11	Level 0
63	MCC 4121 Bus	SWGR 412 - MCC 4121 CB	0.48	27.56	15.59	25.09	14.19	0.172	0.000	Yes	PNL	25	61	18	8.8	Level 3
64	MCC 4121 Typ 100A Load	MCC 4121 Typ 100A CB	0.48	10.22	6.68	10.08	6.59	0.025	0.000	Yes	PNL	25	11	18	0.54	Level 0
65	MCC 4121 Typ 200A Load	MCC 4121 Typ 200A CB	0.48	16.67	10.15	15.86	9.66	0.025	0.000	Yes	PNL	25	15	18	0.84	Level 0
66	MCC 4121 Typ 400A Load	MCC 4121 Typ 400A CB	0.48	21.15	12.44	19.80	11.64	0.025	0.000	Yes	PNL	25	17	18	1.1	Level 0
67	SWGR 11 52-M Bus	SWGR 311 Relay	4.16	12.05	11.66	10.89	10.54	1.917	0.083	Yes	SWG	104	792	36	24	Level 3 (*N9)
68	SWGR 111 52-M Bus	SWGR 111 Relay	4.16	12.02	11.63	10.86	10.51	1.917	0.083	Yes	SWG	104	790	36	24	Level 3 (*N9)
69	SWGR 111 Bus	SWGR 111 52-M Relay	4.16	11.95	11.57	10.80	10.45	1.893	0.083	Yes	SWG	104	775	36	24	Level 3
70	SWGR 112 Bus	SWGR 112 Relay	0.48	67.55	33.53	29.83	14.81	1.917	0.083	Yes	PNL	25	316	18	132	Dangerous! (*N9) (*N21)
71	SWGR 211 52-M Bus	SWGR 211 Relay	4.16	11.96	11.57	10.80	10.45	1.917	0.083	Yes	SWG	104	785	36	24	Level 3 (*N9)
72	SWGR 211 Bus	SWGR 211 52-M Relay	4.16	11.90	11.51	10.74	10.39	1.899	0.083	Yes	SWG	104	773	36	24	Level 3
73	SWGR 212 - MCC 1223 CB Bus	SWGR 112 - MCC 1223 CB	0.48	29.65	16.59	28.99	16.23	0.05	0.000	Yes	PNL	25	31	18	2.9	Level 1 (*N21)
74	SWGR 212 Bus	SWGR 212 Relay	0.48	31.85	17.64	29.41	16.29	1.917	0.083	Yes	PNL	25	290	18	114	Dangerous! (*N9)
75	SWGR 311 Bus	SWGR 311 52-M Relay	4.16	11.98	11.60	10.83	10.48	1.891	0.083	Yes	SWG	104	776	36	24	Level 3
76	SWGR 312 Bus	SWGR 312 Relay	0.48	67.54	33.53	29.63	14.71	1.917	0.083	Yes	PNL	25	315	18	131	Dangerous! (*N9) (*N21)
77	SWGR 411 52-M Bus	SWGR 411 Relay	4.16	11.91	11.53	10.75	10.41	1.377	0.083	Yes	SWG	104	566	36	17	Level 3
78	SWGR 411 Bus	SWGR 411 Relay	4.16	11.85	11.46	10.69	10.34	1.382	0.083	Yes	SWG	104	564	36	17	Level 3 (*N5)
79	SWGR 412 - MCC 3423 CB Bus	SWGR 312 - MCC 3423 CB	0.48	29.65	16.59	28.99	16.23	0.05	0.000	Yes	PNL	25	31	18	2.9	Level 1 (*N21)
80	SWGR 412 Bus	SWGR 412 Relay	0.48	32.19	17.80	29.75	16.45	0.546	0.083	Yes	PNL	25	145	18	37	Level 4
81	XYZ Energy Grid 138kV Bus	MaxTripTime @2.0s	138	42.17	42.17	42.00	42.00	2	0.000	No	AIR	153	2774	18	28376	Dangerous! (*N1) (*N2) (*N9)
82	Unit 2 Refrig Air Compressors	SWGR 211 52-CH	4.16	11.43	9.41	10.43	8.59	0.011	0.000	Yes	SWG	104	3	36	0.12	Level 0 (*N3)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective Device Name	Bus kV	Bus Bolted (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted (kA)	Prot Dev Arcing Fault (kA)	Trip/Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	PPE Level
83	Unit 3 Refrig Air Compressors	SWGR 311 52-CH	4.16	11.51	9.47	10.51	8.65	0.011	0.000	Yes	SWG	104	3	36	0.11	Level 0 (*N3)
84	Unit 4 Refrig Air Compressors	SWGR 411 52-CH	4.16	11.39	9.37	10.39	8.55	0.011	0.000	Yes	SWG	104	3	36	0.12	Level 0 (*N3)
85	Unit 1 & 2 - TIC Panel Main	MCC 1121 LP1121 CB	0.208	2.60	1.69	2.60	1.69	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
86	Unit 1 Refrig Air Compressors	SWGR 111 52-CH	4.16	11.48	9.45	10.49	8.63	0.011	0.000	Yes	SWG	104	3	36	0.11	Level 0 (*N3)
87	Unit 3 & 4 - TIC Panel Main	MCC 3121 LP3121 CB	0.208	2.60	1.69	2.60	1.69	2	0.000	Yes	PNL	25	18	18	1.2	Level 0 (*N9) (*N15)
88	Level 0: Nonmelting or Untreated Fiber with Weight >= 4.5 oz/sq yd	0.0 - 1.2 cal/cm^2													#Level 0 = 42 (*N1) - Out of IEEE 1584 Range, Lee Equation Used.	
89	Level 1: Arc-rated shirt & pants or arc-rated coverall	1.2 - 4.0 cal/cm^2													#Level 1 = 7 (*N2) < 80% Cleared Fault Threshold	
90	Level 2: Arc-rated shirt & pants or arc-rated coverall	4.0 - 8.0 cal/cm^2													#Level 2 = 3 (*N3) - Arcing Current Low Tolerances Used	
91	Level 3: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit	8.0 - 25.0 cal/cm^2													#Level 3 = 10 (*N5) - Miscoordinated, Upstream Device Tripped	
92	Level 4: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit	25.0 - 40.0 cal/cm^2													#Level 4 = 9 (*N9) - Max Arcing Duration Reached	
93	Level Dangerous!: DO NOT WORK ON LIVE!	40.0 - 999.0 cal/cm^2													#Danger = 12 (*N15) - Report as category 0 if fed by one transformer size < 125 kVA	
94															#Equip Eval Failed = 11 (*N21) - Equipment Evaluation Failed, OVERDUTIED EQUIPMENT FOUND - Inappropriate to provide arc-flash	
95	For additional information refer to NFPA 70 E, Standard for Electrical Safety in the Workplace.									NFPA 70E 2012 Annex D.7 - IEEE 1584 Bus Report (- 80% Cleared Fault Threshold, include Ind. Motors for 5.0 Cycles), mis-coordination checked						
96	Level 0: Nonmelting or Untreated Fiber with Weight >= 4.5 oz/sq yd, Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Safety glasses, Non-melting or untreated natural fiber (cotton/wool/rayon/silk > 4.5 oz/sq yd), shirt (long-sleeve), pants (long), > 50V voltage rated tools + Class 0 (minimum) gloves, Dielectric shoes or insulating mat (step and touch potential).															
97	Level 1: Arc-rated shirt & pants or arc-rated coverall , Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield., 4 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long), or Arc-rated coverall, plus arc-rated face shield or arc flash suit hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash) as needed., Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective	Bus	Bus	Bus	Prot Dev	Prot Dev	Trip/	Breaker	Ground	Equip	Gap	Arc	Working	Incident	PPE Level
2		Device	kV	Bolted	Arcing	Bolted	Arcing	Delay	Opening		Type	(mm)	Flash	Distance	Energy	
3		Name		Fault	Fault	Fault	Fault	Time	Time/Tol				Boundary	(in)	(cal/cm2)	
4				(kA)	(kA)	(kA)	(kA)	(sec.)	(sec.)				(in)			
98	Level 2: Arc-rated shirt & pants or arc-rated coverall , Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 8 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long), or Arc-rated coverall, plus arc-rated flash suit hood or arc-rated face shield and arc rated balaclava, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash)., Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
99	Level 3: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit , Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Arc-rated Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 25 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long) plus Arc-rated coverall, plus arc rated arc flash suit jacket, pants, & hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash)., Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
100	Level 4: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit , Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Arc-rated Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 40 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long) plus Arc-rated coverall, plus arc rated arc flash suit jacket, pants, & hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash)., Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
101	Level Dangerous!: DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, No FR Category Found															

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Bus Name	Protective Device Name	Bus kV	DC Bolted Bus Fault (kA)	DC Arcing Bus Fault (kA)	Bus Equivalent Resistance (Ohms)	DC Bolted Prot Dev Fault (kA)	DC Arcing Prot Dev Fault (kA)	Trip/Delay Time (sec.)	Breaker Opening Time/Tol (sec.)	Duration of Arc (sec.)	Multiplier	Working Distance (in)	Arc Flash Boundary (in)	Incident Energy (cal/cm2)	PPE Level
2																
3																
4																
5	Typical DC Bus @ 1min	MaxTripTime @2.0s	0.125	0.600	0.300	0.2082	0.000	0.000	2.000	0.000	2.000	1.0	18	10	0.36	Level 0 (*N2) (*N9)
6	Typical DC Bus @ 8hr	MaxTripTime @2.0s	0.125	0.480	0.240	0.2602	0.000	0.000	2.000	0.000	2.000	1.0	18	9	0.29	Level 0 (*N2) (*N9)
7	Typical DC Bus @ Max	MaxTripTime @2.0s	0.125	0.864	0.432	0.1446	0.000	0.000	2.000	0.000	2.000	1.0	18	12	0.52	Level 0 (*N2) (*N9)
8															(*N2) < 80% Cleared Fault Threshold	
9	DC Arc Flash (ANSI) Bus Report	For additional information refer to NFPA 70 E, Standard for Electrical Safety in the Workplace.													(*N9) - Max Arcing Duration Reached	
10	Level 0: Nonmelting or Untreated Fiber with Weight >= 4.5 oz/sq yd, Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Safety glasses, Non-melting or untreated natural fiber (cotton/wool/rayon/silk > 4.5 oz/sq yd), shirt (long-sleeve), pants (long), > 50V voltage rated tools + Class 0 (minimum) gloves, Dielectric shoes or insulating mat (step and touch potential).															
11	Level 1: Arc-rated shirt & pants or arc-rated coverall, Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield., 4 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long), or Arc-rated coverall, plus arc-rated face shield or arc flash suit hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash) as needed., Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
12	Level 2: Arc-rated shirt & pants or arc-rated coverall, Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Leather Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 8 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long), or Arc-rated coverall, plus arc-rated flash suit hood or arc-rated face shield and arc rated balaclava, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash), Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
13	Level 3: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit, Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Arc-rated Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 25 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long) plus Arc-rated coverall, plus arc rated arc flash suit jacket, pants, & hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash), Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
14	Level 4: Arc-rated shirt & pants + arc-rated coverall + arc-rated arc flash suit, Hardhat + Arc-rated hard hat liner + Safety Glasses or Goggles + Ear Canal Inserts, Arc-rated Gloves, Leather work shoes, Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection., 40 cal/sq cm, Arc-rated shirt (long-sleeve) plus Arc-rated pants (long) plus Arc-rated coverall, plus arc rated arc flash suit jacket, pants, & hood, Arc-rated rainwear as needed., > 50V voltage rated tools + Class 0 (minimum) gloves and leather protectors (flash), Leather shoes (flash) as needed. Dielectric shoes or insulating mat (step and touch potential).															
15	Level Dangerous!: DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, DO NOT WORK ON LIVE!, No FR Category Found															

XYZ

xyz

Typical SBM Battery Set @ 1min

Battery Rating 83.900 A
Rated Voltage 125.000 V
Battery Size Type ONE_MINUTE
Number of Positive Plates 15
Battery Type NICKEL_CADMIUM
Number of Cells 90

dcCBL-0001
Length 10.00 ft

Typical SBM Battery Set @ 8hr

Battery Rating 6.700 A
Rated Voltage 125.000 V
Battery Size Type EIGHT_HOURS
Number of Positive Plates 15
Battery Type NICKEL_CADMIUM
Number of Cells 90

dcCBL-0003
Length 10.00 ft

Typical SBM Battery Set @ Max

Battery Rating 840.000 A
Rated Voltage 125.000 V
Battery Size Type MAX_SC
Number of Positive Plates 15
Battery Type NICKEL_CADMIUM
Number of Cells 90

dcCBL-0004
Length 10.00 ft

Typical DC Bus @ 1min

System Nominal DC Voltage 125.0 V
AF_BoltedFault 0.600 kA
AF_TripTime 2.000 s
AF_IncidentEnergy 0.36 Cal/cm²
AF_PPE Category 0
AF_Boundary 9.85 inches
AF_ArcingFault 0.300 kA

Typical DC Bus @ 8hr

System Nominal DC Voltage 125.0 V
AF_BoltedFault 0.480 kA
AF_TripTime 2.000 s
AF_IncidentEnergy 0.29 Cal/cm²
AF_PPE Category 0
AF_Boundary 8.81 inches
AF_ArcingFault 0.240 kA

Typical DC Bus @ Max

System Nominal DC Voltage 125.0 V
AF_BoltedFault 0.864 kA
AF_TripTime 2.000 s
AF_IncidentEnergy 0.52 Cal/cm²
AF_PPE Category 0
AF_Boundary 11.81 inches
AF_ArcingFault 0.432 kA

XYZ
Arc Flash Study - Typical DC Model Drawing
e-Hazard - Louisville, KY
J. D. Aeiker May 3, 2017 Rev. 0

	A	B	C	D	E	F	G
1	Device/Bus	Status	Description	Voltage (V)	Continuous Amps	INT kA	Rating%
2	Manufacturer			Bus/Device	LF/Dev/Rating%	Calc/Dev/Series	Volt/INT/C-L
3	MCC 1121 - MCC 1121A CB	Pass	SFLA, Spectra RMS	480	0.00	48.63	100.00
4	MCC 1121 Bus		70-250A	480	200.00	65.00	74.82
5	GE		SFLA		0.00		
6							
7	MCC 1121 LP1121 CB	Pass	SELA, Spectra RMS	480	0.00	48.63	100.00
8	MCC 1121 Bus		15-150A	480	100.00	65.00	74.82
9	GE		SELA		0.00		
10							
11	MCC 1121 Typ 100A CB	Pass	SELA, Spectra RMS	480	37.14	48.63	100.00
12	MCC 1121 Bus		15-150A	480	100.00	65.00	74.82
13	GE		SELA		37.14		
14							
15	MCC 1121 Typ 200A CB	Pass	SFLA, Spectra RMS	480	155.07	48.63	100.00
16	MCC 1121 Bus		70-250A	480	200.00	65.00	74.82
17	GE		SFLA		77.53		
18							
19	MCC 1121 Typ 400A CB	Pass	SGLA, Spectra RMS	480	247.87	48.63	100.00
20	MCC 1121 Bus		125-600A	480	600.00	65.00	74.82
21	GE		SGLA		41.31		
22							
23	MCC 1121A Main CB	Pass	HKD	480	0.00	13.25	100.00
24	MCC 1121A Main @ Demin H2O		100-400A	480	250.00	65.00	20.39
25	CUTLER-HAMMER		HKD		0.00		
26							
27	MCC 1122 LPCT CB	Pass	HKD	480	0.00	17.27	100.00
28	MCC 1122 Bus		100-400A	480	250.00	65.00	26.57
29	CUTLER-HAMMER		HKD		0.00		
30							
31	MCC 1122 Main CB	Pass	HND, RMS 310	480	136.96	17.42	100.00
32	MCC 1122 Main @ CT Bldg		LSI, 400-800A Adj Plug	480	800.00	65.00	26.81
33	CUTLER-HAMMER		HND		17.12		
34							
35	MCC 1122 Typ CT Drive CB	Pass	HMCP	480	12.43	17.27	100.00
36	MCC 1122 Bus		30A (90-300A Inst)	480	30.00	65.00	26.57
37	CUTLER-HAMMER		HMCP		41.42		
38							
39	MCC 1122 Typ CT Fan CB	Pass	HMCP	480	124.53	17.27	100.00
40	MCC 1122 Bus		150A (750-2500A Inst)	480	150.00	65.00	26.57
41	CUTLER-HAMMER		HMCP		83.02		
42							
43	MCC 1223 LP12A & 12S CB	Pass	HKD	480	0.00	41.71	100.00
44	MCC 1223 MLO Bus		100-400A	480	100.00	65.00	64.16
45	CUTLER-HAMMER		HKD		0.00		
46							
47	MCC 1223 Typ CW Pump CB	Pass	HKD	480	154.75	41.71	100.00
48	MCC 1223 MLO Bus		100-400A	480	300.00	65.00	64.16
49	CUTLER-HAMMER		HKD		51.58		
50							
51	MCC 1223 Typ Drive CB	Pass	HMCP	480	12.37	41.71	100.00
52	MCC 1223 MLO Bus		30A (90-300A Inst)	480	30.00	65.00	64.16
53	CUTLER-HAMMER		HMCP		41.24		
54							
55	MCC 2121 LP2121 CB	Pass	SELA, Spectra RMS	480	0.00	27.32	100.00
56	MCC 2121 Bus		15-150A	480	100.00	65.00	42.02
57	GE		SELA		0.00		
58							

	A	B	C	D	E	F	G
1	Device/Bus	Status	Description	Voltage (V)	Continuous Amps	INT kA	Rating%
2	Manufacturer			Bus/Device	LF/Dev/Rating%	Calc/Dev/Series	Volt/INT/C-L
59	MCC 2121 Typ 100A CB	Pass	SELA, Spectra RMS	480	36.85	27.32	100.00
60	MCC 2121 Bus		15-150A	480	100.00	65.00	42.02
61	GE		SELA		36.85		
62							
63	MCC 2121 Typ 200A CB	Pass	SFLA, Spectra RMS	480	153.86	27.32	100.00
64	MCC 2121 Bus		70-250A	480	200.00	65.00	42.02
65	GE		SFLA		76.93		
66							
67	MCC 2121 Typ 400A CB	Pass	SGLA, Spectra RMS	480	245.94	27.32	100.00
68	MCC 2121 Bus		125-600A	480	600.00	65.00	42.02
69	GE		SGLA		40.99		
70							
71	MCC 3121 - MCC 3121A CB	Pass	SFLA, Spectra RMS	480	0.00	56.58	100.00
72	MCC 3121 Bus		70-250A	480	250.00	65.00	87.05
73	GE		SFLA		0.00		
74							
75	MCC 3121 LP3121 CB	Pass	SELA, Spectra RMS	480	0.00	56.58	100.00
76	MCC 3121 Bus		15-150A	480	100.00	65.00	87.05
77	GE		SELA		0.00		
78							
79	MCC 3121 Typ 100A CB	Pass	SELA, Spectra RMS	480	37.09	56.58	100.00
80	MCC 3121 Bus		15-150A	480	100.00	65.00	87.05
81	GE		SELA		37.09		
82							
83	MCC 3121 Typ 200A CB	Pass	SFLA, Spectra RMS	480	154.85	56.58	100.00
84	MCC 3121 Bus		70-250A	480	200.00	65.00	87.05
85	GE		SFLA		77.42		
86							
87	MCC 3121 Typ 400A CB	Pass	SGLA, Spectra RMS	480	247.52	56.58	100.00
88	MCC 3121 Bus		125-600A	480	600.00	65.00	87.05
89	GE		SGLA		41.25		
90							
91	MCC 3121A Main CB	Pass	HKD	480	0.00	7.54	100.00
92	MCC 3121A Main @ Demin H2O		100-400A	480	250.00	65.00	11.60
93	CUTLER-HAMMER		HKD		0.00		
94							
95	MCC 3122 Chem Bldg LP CB	Pass	HKD	480	0.00	50.35	100.00
96	MCC 3122 Bus		100-400A	480	100.00	65.00	77.47
97	CUTLER-HAMMER		HKD		0.00		
98							
99	MCC 3122 Main CB	Pass	SS, SH PowerBreak II, MVT Plus/PM	480	136.22	51.58	100.00
100	MCC 3122 Main @ CT Bldg		LSI, 200-2000AS	480	800.00	65.00	79.36
101	GE		SS		17.03		
102							
103	MCC 3122 Typ CT Drive CB	Pass	HMCP	480	12.36	50.35	100.00
104	MCC 3122 Bus		30A (90-300A Inst)	480	100.00	65.00	77.47
105	CUTLER-HAMMER		HMCP		12.36		
106							
107	MCC 3122 Typ CT Fan CB	Pass	HMCP	480	123.86	50.35	100.00
108	MCC 3122 Bus		150A (750-2500A Inst)	480	150.00	65.00	77.47
109	CUTLER-HAMMER		HMCP		82.57		
110							
111	MCC 3423 LP34A & 34S CB	Pass	HKD	480	0.00	41.70	100.00
112	MCC 3423 MLO Bus		100-400A	480	100.00	65.00	64.16
113	CUTLER-HAMMER		HKD		0.00		
114							

	A	B	C	D	E	F	G
1	Device/Bus	Status	Description	Voltage (V)	Continuous Amps	INT kA	Rating%
2	Manufacturer			Bus/Device	LF/Dev/Rating%	Calc/Dev/Series	Volt/INT/C-L
115	MCC 3423 Typ CW Pump CB	Pass	HKD	480	154.75	41.70	100.00
116	MCC 3423 MLO Bus		100-400A	480	300.00	65.00	64.16
117	CUTLER-HAMMER		HKD		51.58		
118							
119	MCC 3423 Typ Drive CB	Pass	HMCP	480	12.37	41.70	100.00
120	MCC 3423 MLO Bus		30A (90-300A Inst)	480	100.00	65.00	64.16
121	CUTLER-HAMMER		HMCP		12.37		
122							
123	MCC 4121 LP4121 CB	Pass	SELA, Spectra RMS	480	0.00	27.56	100.00
124	MCC 4121 Bus		15-150A	480	100.00	65.00	42.39
125	GE		SELA		0.00		
126							
127	MCC 4121 Typ 100A CB	Pass	SELA, Spectra RMS	480	36.85	27.56	100.00
128	MCC 4121 Bus		15-150A	480	100.00	65.00	42.39
129	GE		SELA		36.85		
130							
131	MCC 4121 Typ 200A CB	Pass	SFLA, Spectra RMS	480	153.84	27.56	100.00
132	MCC 4121 Bus		70-250A	480	200.00	65.00	42.39
133	GE		SFLA		76.92		
134							
135	MCC 4121 Typ 400A CB	Pass	SGLA, Spectra RMS	480	245.91	27.56	100.00
136	MCC 4121 Bus		125-600A	480	600.00	65.00	42.39
137	GE		SGLA		40.99		
138							
139	SWGR 111 52-CH	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	172.23	12.03	81.89
140	SWGR 111 Bus		2R-26R	5080	200.00	50.00	24.05
141	CUTLER-HAMMER		CLS, 9R		86.12		22.23
142							
143	SWGR 111 52-CT	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	28.23	12.03	81.89
144	SWGR 111 Bus		2R-26R	5080	100.00	50.00	24.05
145	CUTLER-HAMMER		CLS, 3R		28.23		22.23
146							
147	SWGR 111 52-M	Pass	VB1	4160	200.47	11.58	87.39
148	SWGR 111 52-M Bus		1200-4000A	4760	1200.00	33.18 (*N2)	34.90
149	GE		VB1-4.16-250		16.71		31.22
150							
151	SWGR 111 CB - 991A	Pass	PVDB1	13800	60.43	28.84	89.03
152	13.8kV Bus - SWGR 11		600-3000A	15500	1200.00	40.00	72.10
153	GE		PVDB1-15.5-40000 (5 Cycle)		5.04		66.64
154							
155	SWGR 111 Chiller Heater 1 XFMR	Pass	HLE & CLE, 5.5kV E-Rated	4160	0.00	12.03	75.64
156	SWGR 111 Bus		30E-450E	5500	200.00	63.00	19.09
157	CUTLER-HAMMER		HLE, 200E		0.00		17.79
158							
159	SWGR 112 - MCC 1121 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	442.01	*69.38 (*N1)	100.00
160	SWGR 112 Bus		LSI, 200-2000AS	480	1200.00	65.00	*106.73
161	GE		SS		36.83		
162							
163	SWGR 112 - MCC 1122 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	136.96	*69.38 (*N1)	100.00
164	SWGR 112 Bus		LSI, 200-2000AS	480	800.00	65.00	*106.73
165	GE		SS		17.12		
166							
167	SWGR 112 - MCC 1223 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	167.12	*69.38 (*N1)	100.00
168	SWGR 112 Bus		LSI, 200-2000AS	480	800.00	65.00	*106.73
169	GE		SS		20.89		
170							

	A	B	C	D	E	F	G
1	Device/Bus	Status	Description	Voltage (V)	Continuous Amps	INT kA	Rating%
2	Manufacturer			Bus/Device	LF/Dev/Rating%	Calc/Dev/Series	Volt/INT/C-L
171	SWGR 112 CB - 991B	Pass	PVDB1	13800	25.95	28.84	89.03
172	13.8kV Bus - SWGR 11		600-3000A	15500	1200.00	40.00	72.10
173	GE		PVDB1-15.5-40000 (5 Cycle)		2.16		66.64
174							
175	SWGR 211 52-CH	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	172.19	11.97	81.89
176	SWGR 211 Bus		2R-26R	5080	200.00	50.00	23.94
177	CUTLER-HAMMER		CLS, 9R		86.10		22.14
178							
179	SWGR 211 52-CT	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	28.23	11.97	81.89
180	SWGR 211 Bus		2R-26R	5080	100.00	50.00	23.94
181	CUTLER-HAMMER		CLS, 3R		28.23		22.14
182							
183	SWGR 211 52-M	Pass	VB1	4160	200.42	11.52	87.39
184	SWGR 211 52-M Bus		1200-4000A	4760	1200.00	33.18 (*N2)	34.72
185	GE		VB1-4.16-250		16.70		31.08
186							
187	SWGR 211 CB - 992A	Pass	PVDB1	13800	60.42	28.40	89.03
188	13.8kV Bus - SWGR 21		600-3000A	15500	1200.00	40.00	70.99
189	GE		PVDB1-15.5-40000 (5 Cycle)		5.03		65.83
190							
191	SWGR 211 Chiller Heater 2 XFMR	Pass	HLE & CLE, 5.5kV E-Rated	4160	0.00	11.97	75.64
192	SWGR 211 Bus		30E-450E	5500	200.00	63.00	19.00
193	CUTLER-HAMMER		HLE, 200E		0.00		17.71
194							
195	SWGR 212 - MCC 2121 CB	Pass	SS, SH PowerBreak II, MVT Plus/PM	480	436.65	32.72 (*N1)	100.00
196	SWGR 212 Bus		LSI, 200-2000AS	480	1200.00	65.00	50.33
197	GE		SS		36.39		
198							
199	SWGR 212 CB - 992B	Pass	PVDB1	13800	15.19	28.40	89.03
200	13.8kV Bus - SWGR 21		600-3000A	15500	1200.00	40.00	70.99
201	GE		PVDB1-15.5-40000 (5 Cycle)		1.27		65.83
202							
203	SWGR 311 52-CH	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	172.23	12.06	81.89
204	SWGR 311 Bus		2R-26R	5080	200.00	50.00	24.12
205	CUTLER-HAMMER		CLS, 9R		86.11		22.30
206							
207	SWGR 311 52-CT	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	28.23	12.06	81.89
208	SWGR 311 Bus		2R-26R	5080	100.00	50.00	24.12
209	CUTLER-HAMMER		CLS, 3R		28.23		22.30
210							
211	SWGR 311 52-M	Pass	VB1	4160	200.46	11.61	87.39
212	SWGR 11 52-M Bus		1200-4000A	4760	1200.00	33.18 (*N2)	34.99
213	GE		VB1-4.16-250		16.70		31.31
214							
215	SWGR 311 CB - 993A	Pass	PVDB1	13800	60.43	28.76	89.03
216	13.8kV Bus - SWGR 31		600-3000A	15500	1200.00	40.00	71.89
217	GE		PVDB1-15.5-40000 (5 Cycle)		5.04		66.44
218							
219	SWGR 311 Chiller Heater 3 XFMR	Pass	HLE & CLE, 5.5kV E-Rated	4160	0.00	12.06	75.64
220	SWGR 311 Bus		30E-450E	5500	200.00	63.00	19.14
221	CUTLER-HAMMER		HLE, 200E		0.00		17.84
222							
223	SWGR 312 - MCC 3121 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	437.54	*69.37 (*N1)	100.00
224	SWGR 312 Bus		LSI, 200-2000AS	480	1200.00	65.00	*106.73
225	GE		SS		36.46		
226							

	A	B	C	D	E	F	G	
1	Device/Bus	Status	Description	Voltage (V)	Continuous Amps	INT kA	Rating%	
2	Manufacturer			Bus/Device	LF/Dev/Rating%	Calc/Dev/Series	Volt/INT/C-L	
227	SWGR 312 - MCC 3122 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	136.22	*69.37 (*N1)	100.00	
228	SWGR 312 Bus		LSI, 200-2000AS	480	800.00	65.00	*106.73	
229	GE		SS		17.03			
230								
231	SWGR 312 - MCC 3423 CB	Fail	SS, SH PowerBreak II, MVT Plus/PM	480	167.12	*69.37 (*N1)	100.00	
232	SWGR 312 Bus		LSI, 200-2000AS	480	800.00	65.00	*106.73	
233	GE		SS		20.89			
234								
235	SWGR 312 CB - 993B	Pass	PVDB1	13800	25.77	28.76	89.03	
236	13.8kV Bus - SWGR 31		600-3000A	15500	1200.00	40.00	71.89	
237	GE		PVDB1-15.5-40000 (5 Cycle)		2.15		66.44	
238								
239	SWGR 411 52-CH	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	172.20	11.92	81.89	
240	SWGR 411 Bus		2R-26R	5080	200.00	50.00	23.84	
241	CUTLER-HAMMER		CLS, 9R		86.10		22.04	
242								
243	SWGR 411 52-CT	Pass	CLS-1, -2, -22, 2.8-5.08kV R-Rated	4160	28.23	11.92	81.89	
244	SWGR 411 Bus		2R-26R	5080	100.00	50.00	23.84	
245	CUTLER-HAMMER		CLS, 3R		28.23		22.04	
246								
247	SWGR 411 52-M	Pass	VB1	4160	200.43	11.47	87.39	
248	SWGR 411 52-M Bus		1200-4000A	4760	1200.00	33.18 (*N2)	34.57	
249	GE		VB1-4.16-250		16.70		30.94	
250								
251	SWGR 411 CB - 994A	Pass	PVDB1	13800	60.42	28.40	89.03	
252	13.8kV Bus - SWGR 41		600-3000A	15500	1200.00	40.00	70.99	
253	GE		PVDB1-15.5-40000 (5 Cycle)		5.04		65.83	
254								
255	SWGR 411 Chiller Heater 4 XFMR	Pass	HLE & CLE, 5.5kV E-Rated	4160	0.00	11.92	75.64	
256	SWGR 411 Bus		30E-450E	5500	200.00	63.00	18.92	
257	CUTLER-HAMMER		HLE, 200E		0.00		17.63	
258								
259	SWGR 412 - MCC 4121 CB	Pass	SS, SH PowerBreak II, MVT Plus/PM	480	436.60	33.05 (*N1)	100.00	
260	SWGR 412 Bus		LSI, 200-2000AS	480	1200.00	65.00	50.84	
261	GE		SS		36.38			
262								
263	SWGR 412 CB - 994B	Pass	PVDB1	13800	15.19	28.40	89.03	
264	13.8kV Bus - SWGR 41		600-3000A	15500	1200.00	40.00	70.99	
265	GE		PVDB1-15.5-40000 (5 Cycle)		1.27		65.83	
266								
267								
268	(*N1) System X/R higher than Test X/R, Calc INT kA modified based on low voltage factor.							
269	ISIMISIMISIMSKM ISIM							
270	(*Calc INT kA) Device did not pass. Device is either Marginal (90%) or Failed (100%) of the device library interrupting rating.							

40 cal/cm² ARC 4
PPE Min. Arc Rating

25 cal/cm² ARC 3
PPE Min. Arc Rating

8 cal/cm² ARC 2
PPE Min. Arc Rating

4 cal/cm² ARC 1
PPE Min. Arc Rating

Best Practices

for Exposure up to: **1.2 cal/cm²**

Head

Body

Hands

Feet

40 cal/cm² Arc Rating

Rated Flash Hood

Hard Hat

Safety Glasses/Goggles

Hearing Protection

Rated long sleeve Shirt & Rated Pants or **Rated Coverall** or **Rated Arc Flash Suit**

Rated Gloves or **Rubber Insulating Gloves with Leather Protectors**

Leather Work Shoes

25 cal/cm² Arc Rating

Rated Flash Hood

Hard Hat

Safety Glasses/Goggles

Hearing Protection

Rated long sleeve Shirt & Rated Pants or **Rated Coverall** or **Rated Arc Flash Suit**

Rated Gloves or **Rubber Insulating Gloves with Leather Protectors**

Leather Work Shoes

8 cal/cm² Arc Rating

Rated Face Shield with Rated Balaclava or **Rated Face Shield**

Hard Hat

Safety Glasses/Goggles

Hearing Protection

Rated long sleeve Shirt & Rated Pants or **Rated Coverall** or **Rated Arc Flash Suit**

Heavy Duty Leather Gloves or **Rubber Insulating Gloves with Leather Protectors**

Leather Work Shoes

4 cal/cm² Arc Rating

Rated Face Shield or **Rated Face Shield**

Hard Hat

Safety Glasses/Goggles

Hearing Protection

Rated long sleeve Shirt & Rated Pants or **Rated Coverall** or **Rated Arc Flash Suit**

Heavy Duty Leather Gloves or **Rubber Insulating Gloves with Leather Protectors**

Leather Work Shoes

Eye and Hearing Protection

Long sleeve **Shirt**
Long **Pants**
Undergarments

*ALL Clothing Made of **Nonmelting** or **Untreated Natural Fiber***

Heavy Duty Leather Gloves

EH Leather Work Shoes

Best Practices

- Rated Undergarments**
- DI/EH Work Shoes**
- Rated Hard Hat Liner**
- Rated Jacket, Parka, or Rainwear**

- Dielectric Shoes**
- Working under powerlines
 - High step-potential risk
 - Wet conditions

- Required by NFPA 70E
- Required, Choices Available
- As Needed
- Recommended Best Practice

Check to be sure you have correct **Arc-Rated**

Personal
Protective
Equipment *for the task*

Are You Protected?

e-Hazard
Taking the Flash Out of Electrical Safety

(502) 716-7073
e-Hazard.com



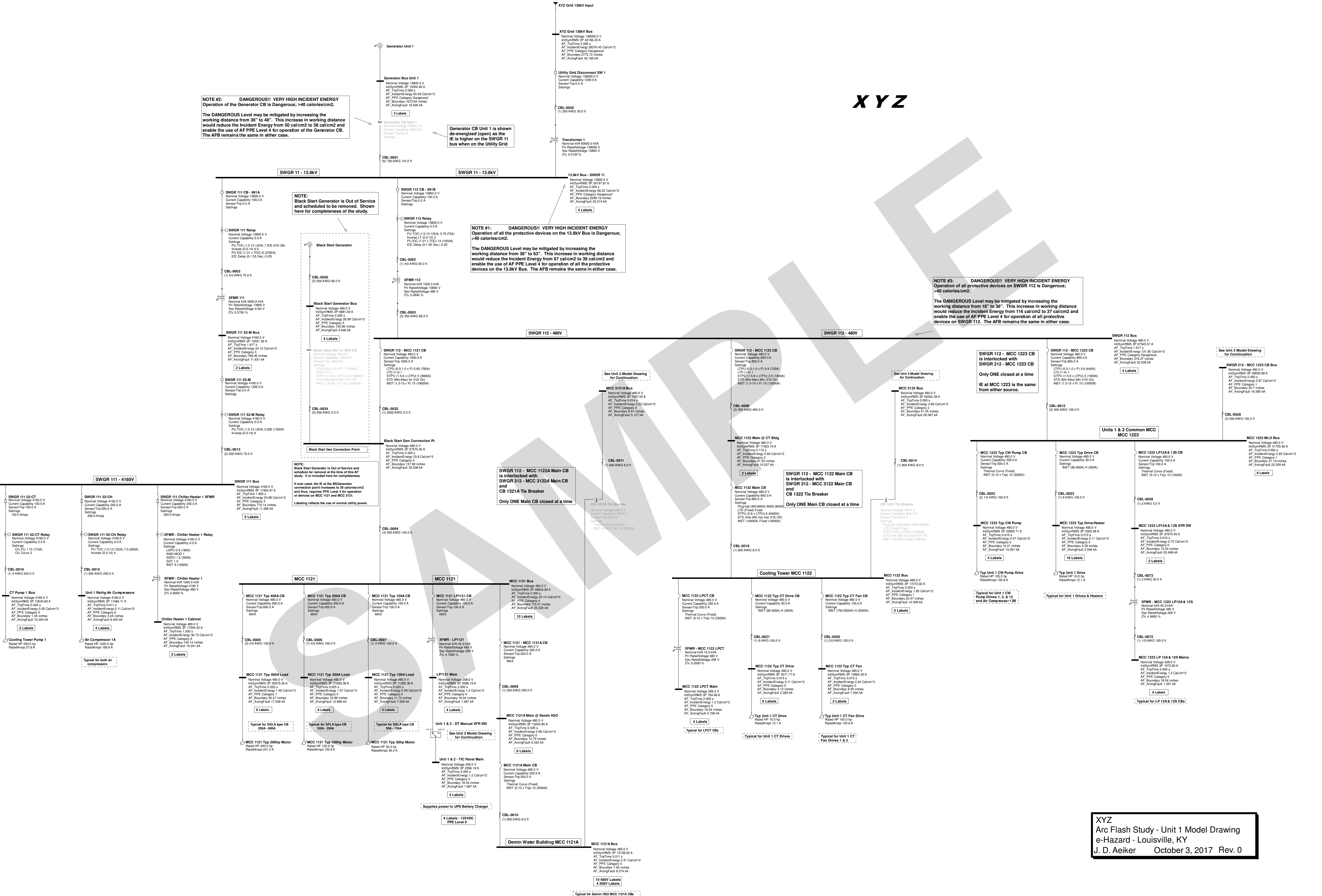
XYZ

NOTE #2: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of the Generator CB is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 48". This increase in working distance would reduce the Incident Energy from 50 cal/cm2 to 38 cal/cm2 and enable the use of AF PPE Level 4 for operation of the Generator CB. The AFB remains the same in either case.

Generator CB Unit 1 is shown deenergized (open) as the IE is higher on the SWGR 11 bus when on the Utility Grid

NOTE #1: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all the protective devices on the 13.8kV Bus is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 53". This increase in working distance would reduce the Incident Energy from 67 cal/cm2 to 58 cal/cm2 and enable the use of AF PPE Level 4 for operation of all the protective devices on the 13.8kV Bus. The AFB remains the same in either case.

NOTE #3: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all protective devices on SWGR 112 is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 18" to 36". This increase in working distance would reduce the Incident Energy from 116 cal/cm2 to 37 cal/cm2 and enable the use of AF PPE Level 4 for operation of all protective devices on SWGR 112. The AFB remains the same in either case.



XYZ Arc Flash Study - Unit 1 Model Drawing e-Hazard - Louisville, KY J. D. Aeiker October 3, 2017 Rev. 0

NOTE #2: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of the Generator CB is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 48". This increase in working distance would reduce the Incident Energy from 50 cal/cm2 to 38 cal/cm2 and enable the use of AF PPE Level 4 for operation of the Generator CB. The AFB remains the same in either case.

Generator CB Unit 2 is shown de-energized (open) as the IE is higher on the SWGR 21 bus when on the Utility Grid

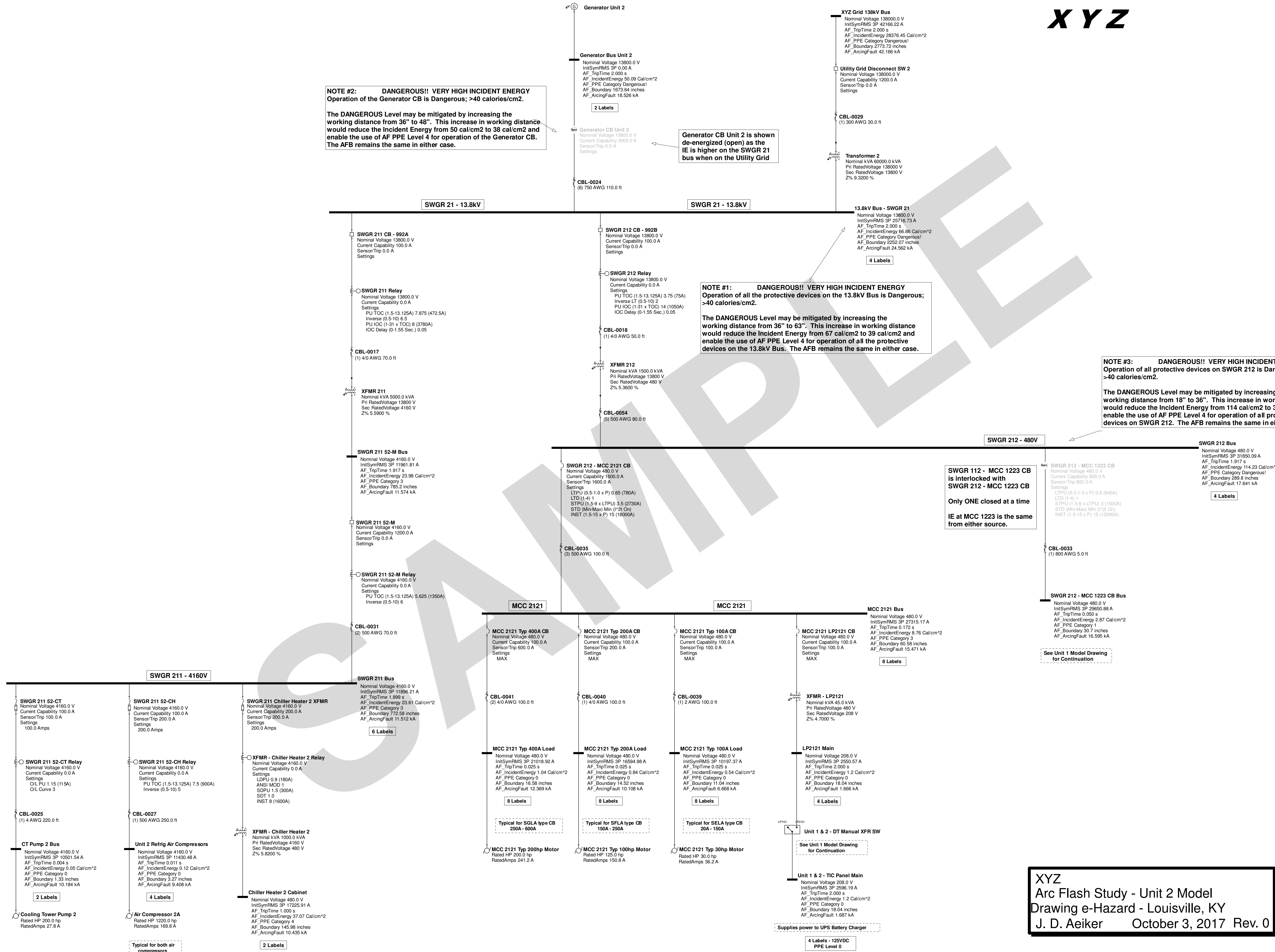
NOTE #1: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all the protective devices on the 13.8kV Bus is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 63". This increase in working distance would reduce the Incident Energy from 67 cal/cm2 to 39 cal/cm2 and enable the use of AF PPE Level 4 for operation of all the protective devices on the 13.8kV Bus. The AFB remains the same in either case.

NOTE #3: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all protective devices on SWGR 212 is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 18" to 36". This increase in working distance would reduce the Incident Energy from 114 cal/cm2 to 37 cal/cm2 and enable the use of AF PPE Level 4 for operation of all protective devices on SWGR 212. The AFB remains the same in either case.

SWGR 112 - MCC 1223 CB is interlocked with SWGR 212 - MCC 1223 CB Only ONE closed at a time IE at MCC 1223 is the same from either source.

See Unit 1 Model Drawing for Continuation

XYZ Arc Flash Study - Unit 2 Model Drawing e-Hazard - Louisville, KY J. D. Aeiker October 3, 2017 Rev. 0



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NOTE #2: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of the Generator CB is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 48". This increase in working distance would reduce the Incident Energy from 50 cal/cm2 to 28 cal/cm2 and enable the use of AF PPE Level 4 for operation of the Generator CB. The AFB remains the same in either case.

Generator CB Unit 3 is shown de-energized (open) as the IE is higher on the SWGR 31 bus when on the Utility Grid

NOTE #1: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all the protective devices on the 13.8kV Bus is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 63". This increase in working distance would reduce the Incident Energy from 67 cal/cm2 to 39 cal/cm2 and enable the use of AF PPE Level 4 for operation of all the protective devices on the 13.8kV Bus. The AFB remains the same in either case.

NOTE #3: DANGEROUS!! VERY HIGH INCIDENT ENERGY Operation of all protective devices on SWGR 312 is Dangerous; >40 calories/cm2. The DANGEROUS Level may be mitigated by increasing the working distance from 18" to 38". This increase in working distance would reduce the Incident Energy from 126 cal/cm2 to 37 cal/cm2 and enable the use of AF PPE Level 4 for operation of all protective devices on SWGR 312. The AFB remains the same in either case.

SWGR 312 - MCC 3423 CB is interlocked with SWGR 412 - MCC 3423 CB. Only ONE closed at a time. IE at MCC 3423 is the same from either source.

SWGR 412 - MCC 3423 CB Bus is interlocked with SWGR 312 - MCC 3423 CB. Only ONE closed at a time. IE at MCC 3423 is the same from either source.

NOTE: Black Start Generator Connection Point (See Unit 1 Model Drawing for Generator) Black Start Gen Connection Pt is Out of Service and schedule for removal at the time of this AF study. It is included here for completeness. If ever used, the IE at the BS Generator connection point increases to 29 calories/cm2 and thus, requires PPE Level 4 for operation of devices on MCC 3121 and MCC 3121.

Typical for Unit 1 CW Pump Drives 3, 4, 5 and Air Compressor 34B

Typical for Unit 3 Drives and Heaters

Typical for Unit 1 CW Fan Drives 3, 4, 5

Typical for Unit 3 CT Drives

Typical for LP 34A & 34S CBs

XYZ Arc Flash Study - Unit 3 Model Drawing e-Hazard - Louisville, KY J. D. Aeiker October 3, 2017 Rev. 0

NOTE #2: DANGEROUS!! VERY HIGH INCIDENT ENERGY
Operation of the Generator CB is Dangerous; >40 calories/cm².
 The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 48". This increase in working distance would reduce the Incident Energy from 50 cal/cm² to 38 cal/cm² and enable the use of AF PPE Level 4 for operation of the Generator CB. The AFB remains the same in either case.

Generator CB Unit 4 is shown de-energized (open) as the IE is higher on the SWGR 41 bus when on the Utility Grid

NOTE #1: DANGEROUS!! VERY HIGH INCIDENT ENERGY
Operation of all the protective devices on the 13.8kV Bus is Dangerous; >40 calories/cm².
 The DANGEROUS Level may be mitigated by increasing the working distance from 36" to 63". This increase in working distance would reduce the Incident Energy from 67 cal/cm² to 39 cal/cm² and enable the use of AF PPE Level 4 for operation of all the protective devices on the 13.8kV Bus. The AFB remains the same in either case.

SWGR 312 - MCC 3423 CB is interlocked with SWGR 412 - MCC 3423 CB
 Only ONE closed at a time
 IE at MCC 3423 is the same from either source.

