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BioMass PDU Electrical Design Study UPDATE

Jake P. Gentle
Kurt S. Myers
Thomas L. Baldwin
Jason W. Bush

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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SUMMARY

The BioMass Process Demonstration Unit (PDU) electrical system is used for the power distribution and control of the many motors and process required loads. Study requirements include a complete system analysis and equipment evaluation, which includes conductor sizing, transformer sizing, breaker and fuse sizing, short-circuit analysis, load-flow analysis, protective-device coordination, arc-flash-hazard analysis, and a multi-state code and grounding review. The SKM System Analysis, Inc., software package was used to model the electrical system, and the input data used can be found in Appendix A. In addition, an electrical inspection walk thru was performed for code compliance, and the findings can be found in emails located in Appendix G. A complete set of ANSI A_Fault drawings are located in Appendix I.

The A_FAULT package was used to calculate the short-circuit analysis. The short-circuit analysis report can be found in Appendix B and shows a variety of information, but the main points to observe are the values from the three-phase fault, the single-line to ground fault, and their X/R ratio values, respectably.

Load flow analyses are performed to ensure that the electrical system can transfer power from the source to the loads in a stable and reliable manner. Load flows also help determine whether transformers and conductors are properly sized or if they will become overloaded. The results from the load flow analysis report can be found in Appendix C and show that some equipment could be overloaded at full load levels. The load-flow currents are used to monitor the ampacity rating limits of the cables to be sure that the sizing of each conductor was properly done. The following conductors have the potential to be overloaded as is shown in the equipment evaluation report found in Appendix F.

- Both motor control center (MCC)1 cable (CBL)21 and MCC1 CBL22 have a design ampacity value of 301.51amps and a 4/0 American wire guage (AWG) cable rated at 230 amps. Consider upsizing these cables to a 350-kcmil-size cable rated at 310 amps.
- MCC1 CBL5 has a design ampacity value of 544.53 amps and a 500 kcmil cable rated at 380 amps. Consider upsizing this cable to a 1000-kcmil-size cable rated at 545 amps.
- MCC2 CBL27 has a design ampacity value of 75.38 amps and an 8 AWG cable rated at 50 amps. Consider upsizing this cable to a 4/0-AWG-size cable rated at 85 amps.

- Both MCC4 CBL48 and MCC4 CBL50 have a design ampacity value of 376.89 amps and a 350 kcmil cable rated at 310 amps. Consider upsizing these cables to a 500–kcmil-size cable rated at 380 amps.
- MCC4 CBL5 has a design ampacity value of 476.99 amps and a 500 kcmil cable rated at 380 amps. Consider upsizing this cable to an 800 kcmil size cable rated at 490 amps.
- MCC1 transformer (Xfrmr)1 has a design ampacity value of 11.25 amps and an ampacity rating of 10.8 amps. Consider upsizing this transformer to a 15-KVA-size rated for 18 amps.
- MCC2 Xfrmr0* has a design ampacity value of 21.46 amps and an ampacity rating of 10.8 amps. Consider upsizing this transformer to a 22.5 kVA size rated for 27 amps. *Note: It has been determined that the current cabinet in which this transformer is located can support up to a 15 KVA transformer. A 22.5 kVA transformer would require a new cabinet. The control-trailer load (approximately 30 amps) is the major load on this transformer and is not connected or at full load at all times; thus, a 15 kVA transformer would suffice for the other loads and it is believed that a 15 kVA transformer would support the control-trailer load, but would have a reduced life because of the overloading incurred during control-trailer loading.

The protective-device coordination study was performed in order to properly determine whether the breakers and fuses were properly sized and the settings appropriately set in order to protect the system. As part of the protective-device coordination, the Computer Aided Plotting for Time Overcurrent Reporting (CAPTOR) study module was used to plot the time-current coordination (TCC) characteristics of the electrical components to ensure that they protect the different electrical apparatus from possible overload and short-circuit currents. TCC report drawings can be found in Appendix D. This system has been protected with the functionality of the electrical components and the safety of the equipment and personnel working in the area in mind. Coordination has been done to isolate the area of abnormality and not interrupt the performance and operation of the rest of the system. However, our model (see Equipment Evaluation Report in Appendix F) indicates that a possibility for failure exists for breakers MCC1 DC-5, MCC4 AL-2, MCC4 CRF-1, MCC4 DC-1, MCC4 PM-2, MCC4 PMC-1, and MCC4 SC-3.

An arc-flash analysis has been performed on the BioMass PDU electrical system to help provide safety guidance to reduce or prevent injury to workers. The results from the arc flash analysis show four main categories of concern, and the proper clothing and equipment for these categories are identified in section 3.4 as well as in Appendix E.

As part of the BioMass PDU project analysis, a grounding review and multi-state code review was performed. As part of this review, it was suggested that the equipment grounding system and the static/lightning protections systems be integrated into one ground wire system. Figure 4 represents the grounded system as applied to the BioMass PDU application. Figure 5 and Figure 6 show multi-state codes applicable to this system and a map of NEC adoption by state.

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BioMass PDU Electrical Design Study UPDATE

1. Overview

2. Introduction

3. System Study

The BioMass PDU electrical system is used for the power distribution and control of the many motors and process-required loads. Study requirements include a complete system analysis and equipment evaluation, which includes conductor sizing, transformer sizing, breaker and fuse sizing, short-circuit and load-flow analysis, protective-device coordination, arc-flash hazard analysis, and a multi-state code and grounding review. In addition, an electrical-inspection walk thru was performed for code compliance. The findings can be found in emails located in Appendix G.

Input information for all equipment modeled for the BioMass PDU project can be found in Appendix A. A simple one-line diagram of the electrical system can be seen in Figure 1, and the full set of drawings is located in Appendix H.

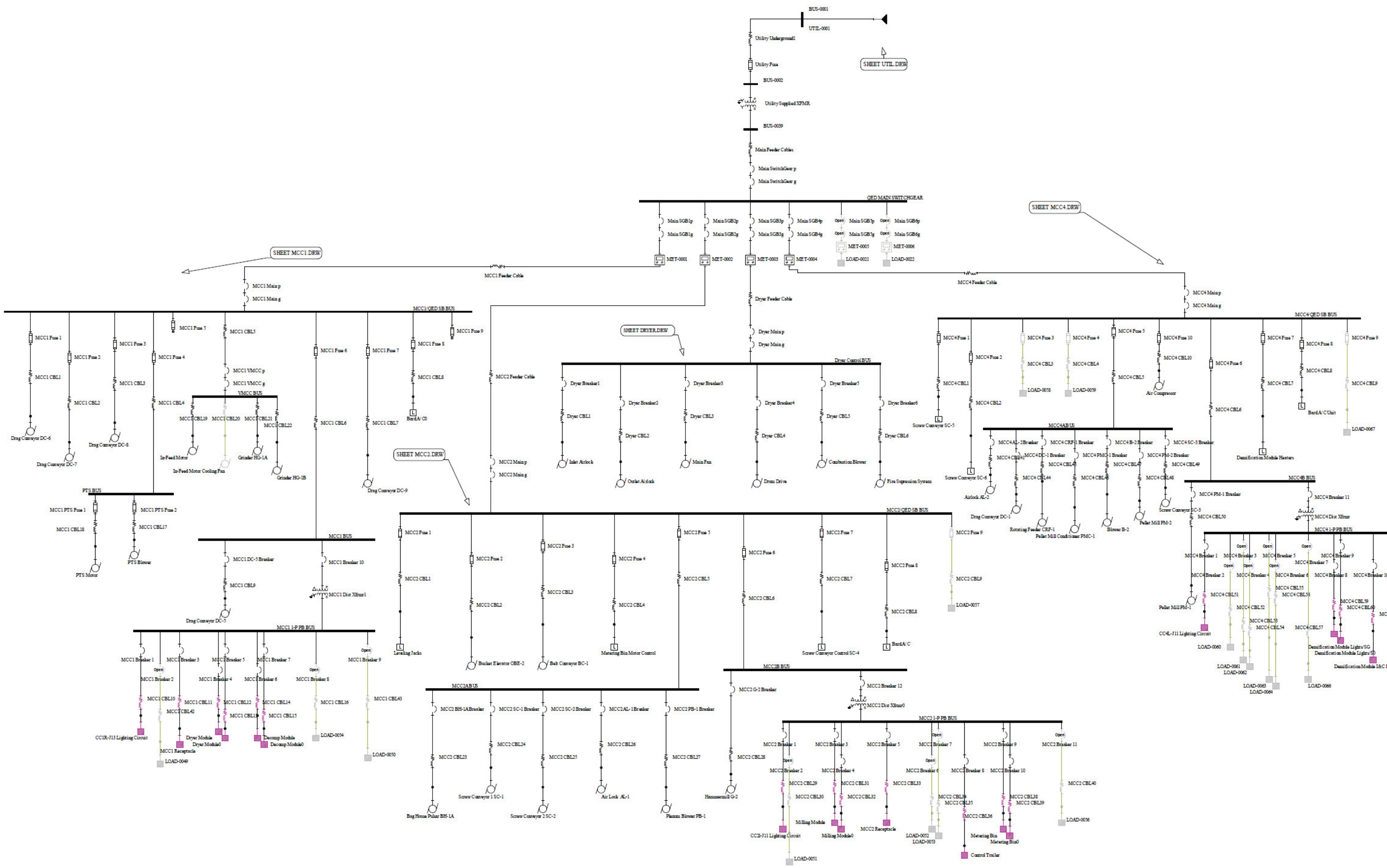

Figure 1: All input one-line diagram.

3.1 Short Circuit Analysis

The A_FAULT package within the SKM System Analysis, Inc., software package that was used to model the electrical system was used to calculate the short circuit analysis. A_FAULT provides the fault calculations in compliance with ANSI C37 standards. The report shows a variety of information, but the main points to observe are the values from the three-phase fault, the single-line to ground fault, and their reactance/resistance (X/R) ratio values, respectably.

Detailed information can be found in Appendix B, but Table 1 shows a summary of the model short circuit analysis results for the buses that are considered contributors of short circuit current. There are a total of 60 faulted buses considered as short circuit contributors by ANSI standards as they are modeled in this system. Some of the busses and their respective fault values are shown in the table below.

Table 1: ANSI short-circuit summary.

F A U L T   S T U D Y   S U M M A R Y
(FOR APPLICATION OF LOW VOLTAGE BREAKERS)
PRE FAULT VOLTAGE: 1.0000
MODEL TRANSFORMER TAPS: NO

BUS RECORD NO NAME	VOLTAGE L-L	A V A I L A B L E F A U L T D U T I E S (KA) 3 PHASE	X/R	LINE/GRND	X/R
BUS-0001	12470.	4.910	14.55	3.575	14.78
BUS-0002	12470.	4.889	11.83	3.557	12.22
BUS-0039	480.	34.397	6.82	0.000	1.00
Dryer Control	480.	16.982	1.69	0.000	1.00
MCC1 1-P PB BU	208.	0.957	0.52	0.960	0.51
MCC1 BUS	480.	28.496	4.36	0.000	1.00
MCC1/QED SB BU	480.	30.070	4.91	0.000	1.00
MCC2 1-P PB BU	208.	0.955	0.52	0.959	0.51
MCC2/QED SB BU	480.	27.728	4.13	0.000	1.00
MCC2A BUS	480.	24.995	2.97	0.000	1.00
MCC2B BUS	480.	25.023	3.59	0.000	1.00
MCC4 1-P PB BU	208.	0.958	0.52	0.960	0.51
MCC4/QED SB BU	480.	30.320	5.10	0.000	1.00
MCC4A BUS	480.	29.393	4.81	0.000	1.00
MCC4B BUS	480.	28.893	4.64	0.000	1.00
PTS BUS	480.	21.210	1.39	0.000	1.00
QED MAIN SWITC	480.	34.243	6.75	0.000	1.00
VMCC BUS	480.	27.963	4.39	0.000	1.00

60 FAULTED BUSES,   93 BRANCHES,   34 CONTRIBUTIONS
UNBALANCED FAULTS REQUESTED

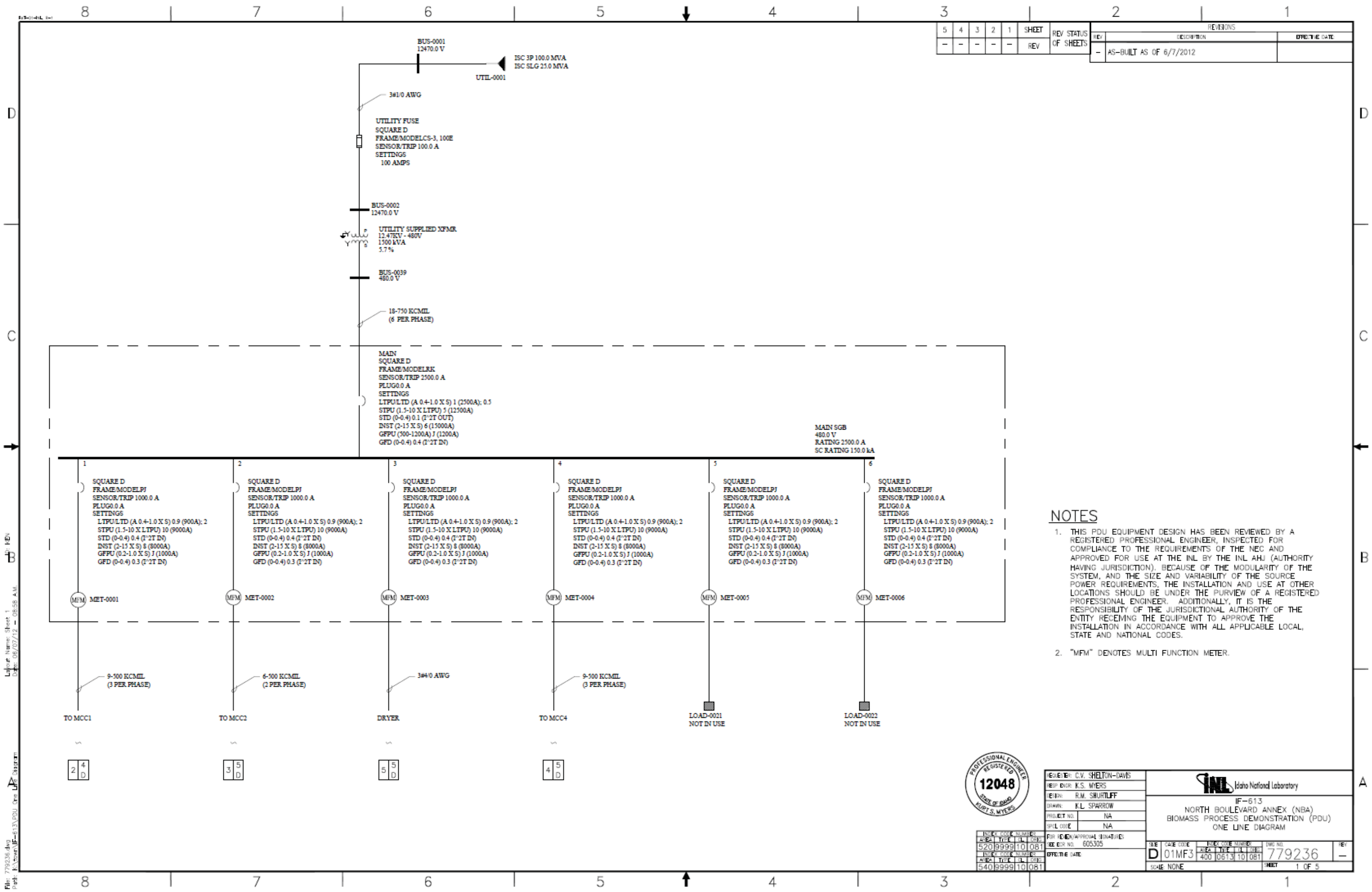

Figure 2. ANSI A_FAULT one-line diagram, sheet 1(Full set of drawings in Appendix I).

The one-line diagram in Figure 2, above, also shows these values next to the corresponding bus, cables, fuses, breakers, and transformers. A complete set of this drawing can be found in Appendix I. These values were used to determine the magnitude of current available at various selected points of the electrical system when a fault occurs. The three-phase fault condition is used to measure the maximum current that will be seen on the system at the selected point during a fault. The point at which the fault occurs is on the source side of the device. This is done to determine whether or not the appropriate device will be able to interrupt the short-circuit current during fault situations.

The short-circuit study gives the ability to determine if the breakers and fuses are capable of interrupting a fault, as well as verifying the appropriate sizing of the switchgear and bus bar sections.

3.2 Load-Flow Analysis

Load-flow analyses are performed to ensure that the electrical system can transfer power from the source to the loads in a stable and reliable manner. Load flows are performed to determine the steady-state operation of the system, as well as calculate the voltage drop on each feeder, bus, and the power flow in all of the branch and feeder circuits within the system. Load flows also help determine whether transformers and conductors are properly sized or they will become overloaded.

The results from the load-flow analysis show that some of the equipment (as specified later in this section) could have the possibility of being overloaded at full load levels; the full–load-flow analysis and the unbalanced system equipment evaluation report can be seen in Appendix C and Appendix F. Table 2 shows the system voltage at the bus, the percent voltage drop at the bus, and the load flow voltage at the bus. However, due to the large size, the table below is only a sample version of the first few buses; for the complete table of all of the buses please see Appendix C, 9.1.

Table 2. Load-flow BUS information.

BUS NAME	System Voltage	(%) VD A	(%) VD B	(%) VD C	LF Voltage (V) A	LF Voltage (V) B	LF Voltage (V) C
BUS-0001	12470	1.03	1.2	1.29	7125	7113	7107
BUS-0002	12470	1.06	1.23	1.31	7123	7111	7105
BUS-0009	480	-1.49	13.59	7.4	281	239	257
BUS-0010	480	-1.64	13.41	7.23	282	240	257
BUS-0012	480	-1.5	13.58	7.39	281	240	257
BUS-0015	480	-1.49	13.59	7.4	281	239	257
BUS-0018	480	-1.4	13.71	7.48	281	239	256
BUS-0019	480	-1.4	13.71	7.48	281	239	256
BUS-0024	480	-1.4	13.71	7.48	281	239	256
BUS-0025	480	-1.4	13.7	7.48	281	239	256
BUS-0029	480	-1.61	13.45	7.25	282	240	257
BUS-0039	480	-2.03	12.96	6.79	283	241	258

Table 2 shows that the voltage drop percentages vary depending on the Phase. The next category that was studied during the load flow analysis was the conductors. Table 3 lists the results found, but as with the previous table, due to the size of this table, the table below only shows a sample of the results; the complete table has been supplied in Appendix C, 9.2.

Table 3. Load-flow conductor information.

BRANCH NAME	FROM NAME	TO NAME	TYPE	Phase	VD%	AMPS	KVA	RATING%
Utility Underground	BUS-0001	BUS-0002	FDR	(A)	0.02	72.47	516.38	48.32
				(B)	0.03	84.5	601.1	56.34
				(C)	0.02	79.55	565.33	53.03
Utility Supplied	BUS-0002	BUS-0039	TX3	(A)	3.09	72.47	516.25	90.74
				(B)	11.73	84.5	600.93	105.81
				(C)	5.48	79.55	565.2	99.6
MCC1 Feeder Cable	QED MAIN SWITCHGEAR	MCC1/QED SB BUS	FDR	(A)	0.3	566.76	160.18	40.2
				(B)	0.35	660.23	159.14	46.82
				(C)	0.33	621.88	160.53	44.1
MCC2 Feeder Cable	QED MAIN SWITCHGEAR	MCC2/QED SB BUS	FDR	(A)	0.32	400.02	113.05	42.55
				(B)	0.36	460.68	111.04	49.01
				(C)	0.36	443.06	114.37	47.13
Dryer Feeder Cable	QED MAIN SWITCHGEAR	Dryer Control	FDR	(A)	0.55	146.58	41.42	63.73
				(B)	0.65	172.32	41.54	74.92
				(C)	0.6	160.69	41.48	69.87
MCC4 Feeder Cable	QED MAIN SWITCHGEAR	MCC4/QED SB BUS	FDR	(A)	0.41	769.43	217.45	54.57
				(B)	0.49	902.15	217.45	63.98
				(C)	0.45	841.01	217.1	59.65
Main Feeder Cable	BUS-0039	QED MAIN SWITCHGEAR	FDR	(A)	0.06	1882.78	532.4	66.06
				(B)	0.07	2195.35	529.57	77.03
				(C)	0.06	2066.62	533.84	72.51

In the tables above, note the amperes and rating percentage of the cables and the transformers. The utility-supplied transformer, as well as other conductors in the complete table in Appendix C, 9.2 and the equipment report in Appendix F, show ampacity ratings higher than the 100% capability of the conductor (also shown below in Table 4).

Table 4. Failed equipment report.

	A	B	C	D	E	F	G	H	I	J	K
1	Device	Status	Bus	Bus	Rated	VD%	LF	Design	Ampacity	LF%	Design%
2				Volts	Volts		Amps	Amps			
3	MCC1 CBL21	Fail	VMCC BUS	480	600	0.26	*259.23	*301.51	230.0	*112.71	*131.09
4	MCC1 CBL22	Fail	VMCC BUS	480	600	0.26	*259.23	*301.51	230.0	*112.71	*131.09
5	MCC1 CBL5	Fail	MCC1/QED SB BUS	480	600	0.17	*520.40	*544.53	380.0	*136.95	*143.30
6	MCC2 CBL27	Fail	MCC2A BUS	480	600	0.73	*65.07	*75.38	50.0	*130.14	*150.76
7											
8	MCC4 CBL48	Fail	MCC4A BUS	480	600	0.25	*324.01	*376.89	310.0	*104.52	*121.58
9	MCC4 CBL5	Fail	MCC4/QED SB BUS	480	600	0.06	*431.36	*476.99	380.0	*113.52	*125.52
10	MCC4 CBL50	Fail	MCC4B BUS	480	600	0.25	*324.04	*376.89	310.0	*104.53	*121.58
11	MCC4 CBL6	Fail	MCC4/QED SB BUS	480	600	0.06	332.18	*384.42	380.0	87.42	*101.16
12											
13	MCC1 Dist Xfrmr1 (Pri)	Fail *(P,S)	MCC1 BUS	480	*480	*3.70	*14.92	*11.25	10.8	*137.83	*103.90
14	MCC2 Dist Xfrmr0 (Pri)	Fail *(P,S)	MCC2B BUS	480	*480	*6.62	*27.79	*21.46	10.8	*256.69	*198.24
15	Utility Supplied XFMR (Pr	Fail *(P,S)	BUS-0002	12470	12470	*4.91	*79.14	*76.31	79.9	*99.09	*95.55

The load flow currents are used to monitor the ampacity rating limits of the cables to be sure that the sizing of each conductor was properly done. It can be seen clearly in Table 6 above which conductors have the potential of being overloaded. Recommendations:

- Both MCC1 CBL21 & MCC1 CBL22 have a design ampacity value of 301.51amps and a 4/0 AWG cable rated at 230 amps. Consider upsizing these cables to a 350 kcmil size cable rated at 310 amps.
- MCC1 CBL5 has a design ampacity value of 544.53 amps and a 500 kcmil cable rated at 380 amps. Consider upsizing this cable to a 1000 kcmil size cable rated at 545 amps.
- MCC2 CBL27 has a design ampacity value of 75.38 amps and an 8 AWG cable rated at 50 amps. Consider upsizing this cable to a 4/0 AWG size cable rated at 85 amps.
- Both MCC4 CBL48 & MCC4 CBL50 have a design ampacity value of 376.89 amps and a 350 kcmil cable rated at 310 amps. Consider upsizing these cables to a 500 kcmil size cable rated at 380 amps.
- MCC4 CBL5 has a design ampacity value of 476.99 amps and a 500 kcmil cable rated at 380 amps. Consider upsizing this cable to an 800 kcmil size cable rated at 490 amps.
- MCC1 Xfrmr1 has a design ampacity value of 11.25 amps and an ampacity rating of 10.8 amps. Consider upsizing this transformer to a 15 KVA size rated for 18 amps.
- MCC2 Xfrmr0* has a design ampacity value of 21.46 amps and an ampacity rating of 10.8 amps. Consider upsizing this transformer to a 22.5 KVA size rated for 27 amps. *Note: It has been determined that the current cabinet this transformer is located in can only support up to a 15 KVA transformer. A 22.5 KVA transformer would require a new cabinet. The control trailer load (approximately 30 amps) is the major load on this transformer and not connected or at full load at all times, thus a 15 KVA transformer would suffice for the other loads and it is believed that a 15 KVA transformer would support the control trailer load but would have a reduced life because of the overloading occurred during the control trailer loading.

Table 5, Table 6, and Table 7 show the load-flow results for the transformer, the utility, the loads, and the motors within the system. Note: again due to size, Table 6 and Table 7 are sample tables, with the complete set of results located in Appendix A, 7.4 and 7.5). Power, both real and reactive (kW and kVAR) have been shown, as well as percent voltage drop and load flow current (A).

Table 5. Load-flow transformer (XFRMR) and utility information.

2-Winding Transformer	Phase	(kW)	(kVAR)	PctVD(%)
Utility Supplied XFRMR	A:	426.3	318.9	3.09
	B:	423.9	317.4	11.73
	C:	425.5	322.4	5.48
MCC1 Dist XFRMR	A:	1.9	1.4	5.26
	B:	1.6	1.2	2.69
	C:	3.2	2.3	0.39
MCC2 Dist XFRMR	A:	4.1	3.1	7.79
	B:	1.7	1.2	2.81
	C:	5.5	4	2.42
MCC4 Dist XFRMR	A:	1.8	1.3	5.1
	B:	1.6	1.2	2.65
	C:	1.6	1.2	2.24

Utility	Phase	(kW)	(kVAR)	PctVD(%)
Utility	A	411.19	312.35	1.03
	B	481.34	360.05	1.2
	C	403.1	396.38	1.29

Table 6. Load-flow general load information.

General Load	Phase	(kW)	(kVAR)	PctVD(%)	LF Current (A)
Leveling Jacks	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Metering Bin MC	A:	17.7	13.3	0.16	78.8
	B:	17.7	13.3	0.19	92.6
	C:	17.7	13.3	0.18	86.4
Screw Conveyor Control SC-4	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Screw Conveyor Control SC-5	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Screw Conveyor Control SC-6	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Densification Module Heaters	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
MCC4 Bard A/C Unit	A:	3	2.3	0.17	13.4
	B:	3	2.3	0.2	15.8
	C:	3	2.3	0.18	14.7
MCC1 Bard A/C Unit	A:	3.1	2.3	0.18	13.8
	B:	2.3	1.7	0.14	11.8
	C:	2.6	1.9	0.15	12.6
MCC2 Bard A/C Unit	A:	2.4	1.8	0.21	10.6
	B:	2.4	1.8	0.25	12.5
	C:	2.4	1.8	0.23	11.7

Table 7. Load-flow induction motor information.

Induction Motor	Phase	(kW)	(kVAR)	PctVD(%)	LF Current (A)	(hp)
Bucket Elevator OBE-2	A:	0.4	0.3	0.02	1.8	1.5
	B:	0.4	0.3	0.02	2.1	
	C:	0.4	0.3	0.02	2	
Drag Conveyor DC-7	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Belt Conveyor BC-1	A:	0.5	0.4	0.03	2.4	2
	B:	0.5	0.4	0.03	2.8	
	C:	0.5	0.4	0.03	2.6	
Drag Conveyor DC-8	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Drag Conveyor DC-6	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Drag Conveyor DC-9	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Inlet Airlock	A:	0.5	0.3	0.03	2	1.5
	B:	0.5	0.3	0.04	2.4	
	C:	0.5	0.3	0.04	2.2	
Outlet Airlock	A:	0.6	0.4	0.04	2.6	1.5
	B:	0.6	0.4	0.05	3	
	C:	0.6	0.4	0.05	2.8	

3.3 Protective Device Coordination

The protective device coordination study was performed in order to determine whether the breakers and fuses were properly sized, with settings appropriately set in order to protect the system. It is ideal to have the protective device interrupt only the section of the system that has the fault; when this is achieved as best as possible, the system is said to be coordinated. The device furthest from the utility was selected as the starting point for the coordination study. Working back towards the utility, the protective device coordination resulted in the following settings (samples shown below in Table 8 and Table 9, with complete tables found in Appendix A, 7.6 and 7.7) for each of the breakers and fuses on the system.

Table 8. Protective-device coordination breaker settings.

LV Breakers	Description	Type	Frame/Sensor/Plug	SETTINGS
Main SwitchGear	SQUARE D	RK	2500.0A	LTPU/LTD (A 0.4-1.0 x S) 1 (2500A); 0.5
	Powerpact R-Frame, 6.0A/P/H		2500.0A	STPU (1.5-10 x LTPU) 5 (12500A)
	LSI, 600-2500A, UL			STD (0-0.4) 0.1 (I^2t Out)
	SQUARE D	RK	2500.0A	INST (2-15 x S) 6 (15000A)
	Powerpact R-Frame, 6.0A/P/H		2500.0A	GFPU (500-1200A) J (1200A)
	GF, 1600-2500AS, UL			GFD (0-0.4) 0.4 (I^2t In)
Main SGB1	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB2	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB3	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB4	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)

Table 9. Protective-device coordination fuse settings.

Fuses	Description	FRAME/MODEL	Cartridge/Trip
Utility Fuse	SQUARE D	CS-3, 100E	100.0A
	CS-3, 15.5kV E-Rated		100.0A
	10E-100E		
MCC1 Fuse 1	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 2	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 3	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 4	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC1 Fuse 5	BUSSMANN	JKS	400.0A
	JKS, 600V Class J		400.0A
	1-600A		
MCC1 Fuse 6	BUSSMANN	JKS	400.0A
	JKS, 600V Class J		400.0A
	1-600A		
MCC1 Fuse 7	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 8	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 9	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC1 PTS Fuse 1	BUSSMANN	LPJ-60SP	60.0A
	LPJ_SP, 600V Class J		60.0A
	15-600A		
MCC1 PTS Fuse 2	BUSSMANN	LPJ-30SP	30.0A
	LPJ_SP, 600V Class J		30.0A
	15-600A		

As part of the protective device coordination, the Computer Aided Plotting for Time Overcurrent Reporting (CAPTOR) study module was used to plot the TCC characteristics of the electrical components to ensure that they protect the various different electrical apparatus from possible overload and short-circuit currents. As part of the study, the locked rotor starting curves were placed on a log-log grid as were the thermal and mechanical damage curves for cables and transformers. Each protective device was then plotted, showing its TCC curve based upon the manufacturer's specifications that were loaded in from the device library.

The following TCC drawing (Figure 3) represents the worst-case path from the largest motor load back to the utility and all of the electrical protection devices in between. Other TCC drawings can be seen in Appendix D.

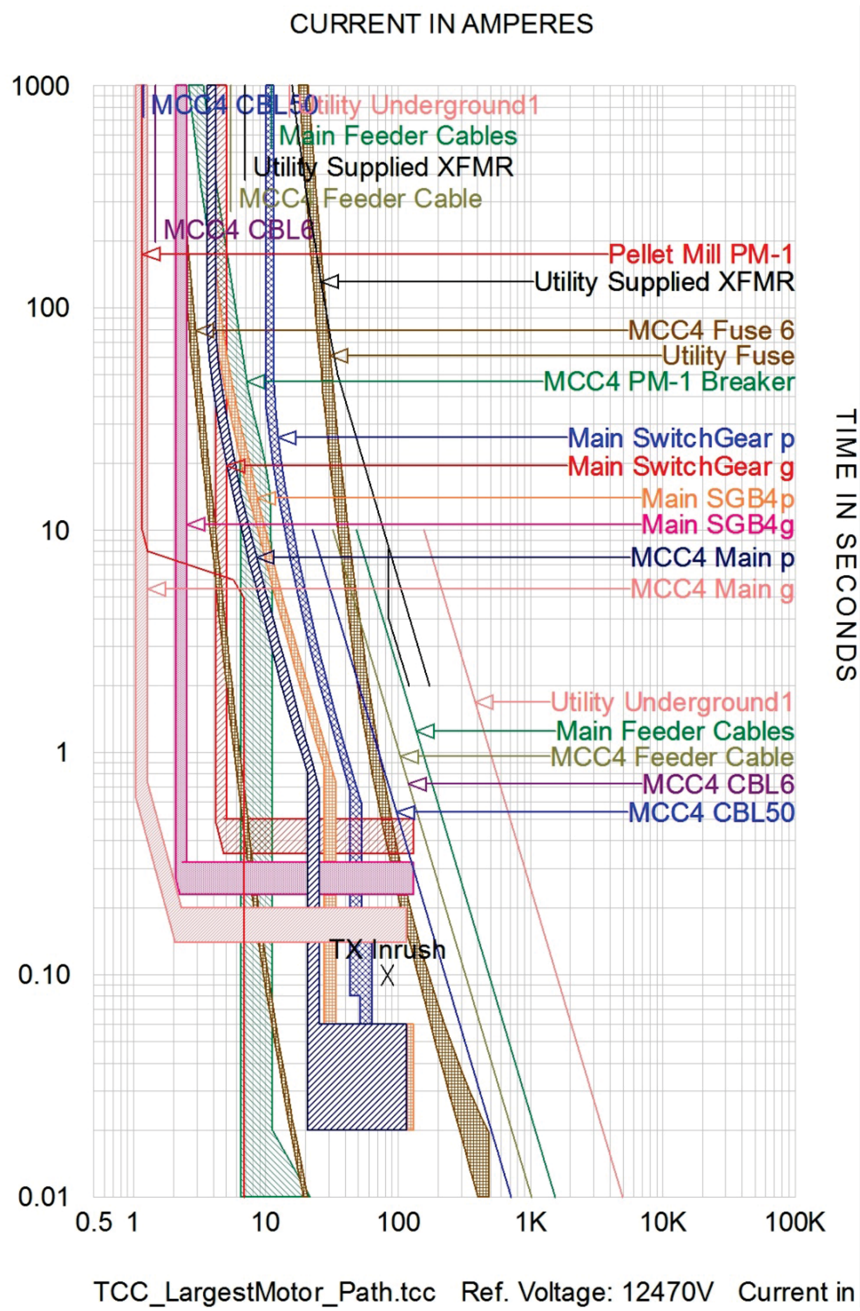

Figure 3. Largest motor TCC drawing for protective-device coordination study.

As shown in the TCC drawing, the coordination of the upstream protective devices is to limit the extent and duration of service interruption during an equipment failure or any other failure on the system. Reducing the amount of damage caused to the system components during such failures is also an objective of the protective-device coordination study. These failures are usually unpredictable, but good engineering design and judgment can reduce the adverse affects that the system can endure.

This system has been protected in concert with the functionality of the electrical components and the safety of the equipment and personnel working in the area. Coordination has been done to isolate the area of abnormality and not to interrupt the performance and operation of the rest of the system. However,

Table 10 shows that a possibility for failure exists for breakers MCC1 DC-5, MCC4 AL-2, MCC4 CRF-1, MCC4 DC-1, MCC4 PM-2, MCC4 PMC-1, and MCC4 SC-3.

Table 10. Breaker failure report.

	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
3	MCC1 DC-5 Breaker	Fail	Powerpact HJ	480	2.58	*28.50	80.00
4	MCC1 BUS		15-150A	600	30.00	25.00	*113.98
5	SQUARE D		HJ		8.60		
7	MCC4 AL-2 Breaker	Fail	Powerpact HJ	480	2.58	*29.39	80.00
8	MCC4A BUS		15-150A	600	30.00	25.00	*117.57
9	SQUARE D		HJ		8.61		
11	MCC4 CRF-1 Breaker	Fail	Powerpact HJ	480	1.29	*29.39	80.00
12	MCC4A BUS		15-150A	600	30.00	25.00	*117.57
13	SQUARE D		HJ		4.31		
15	MCC4 DC-1 Breaker	Fail	Powerpact HJ	480	6.46	*29.39	80.00
16	MCC4A BUS		15-150A	600	30.00	25.00	*117.57
17	SQUARE D		HJ		21.54		
19	MCC4 PM-2 Breaker	Fail	LAL Mag-Gard	480	323.74	*29.39	80.00
20	MCC4A BUS		400A	600	400.00	22.00	*133.61
21	SQUARE D		LAL		80.93		
23	MCC4 PMC-1 Breaker	Fail	Powerpact HJ	480	12.92	*29.39	80.00
24	MCC4A BUS		15-150A	600	30.00	25.00	*117.57
25	SQUARE D		HJ		43.07		
27	MCC4 SC-3 Breaker	Fail	Powerpact HJ	480	6.46	*29.39	80.00
28	MCC4A BUS		15-150A	600	30.00	25.00	*117.57
29	SQUARE D		HJ		21.53		

3.4 Arc Flash Hazard Analysis

An arc-flash analysis has been performed on the BioMass PDU electrical system to help provide safety guidance to reduce or prevent injury to workers. The arc flash analysis also provides workers with the appropriate personal protective equipment (PPE), detailed system modeling and, most importantly, the ability to better protect against loss of life.

The following information regarding the arc flash analysis does not guarantee full protection; it is always suggested to de-energize equipment before performing maintenance. However, this is not always an option, and the following results should aid in the protection of the workers involved. There are a few definitions regarding the information listed within the arc-flash analysis results that need to be described. All definitions have been taken from the SKM Power Tools for Windows Arc Flash Evaluation Study Manager.

- Bus Name: Fault location for bus report. For line side and load side report options the bus refers to the equipment where the line side and load side protective devices are connected.
- Protective Device Name: Refers to the protective device that clears the arcing fault or portion of the total arcing fault current.
- Bus kV: Bus voltage at the fault location.

- Bus Bolted Fault Current (kA): The current flowing to a bus fault that occurs between two or more conductors or bus bars, where the impedance between the conductors is zero.
- Bus Arcing Fault: The calculated arcing current on the faulted bus
- Protective Device Bolted Fault Current (kA): The portion of the total bolted fault current that flows through a given protective device.
- Protective Device Arcing Fault Current (kA): The arc current flowing through each protective device feeding the electric arc fault. Note that the total arc fault current may flow through several parallel sources to the arc location.
- Trip/Delay Time: The time required for the protective device to operate for the given fault condition. In the case of a relay, the breaker opening time is entered separately from the relay trip time. For low voltage breakers and fuses, the trip time is assumed to be the total clearing curve or high tolerance of the published trip curve.
- Breaker Opening Time: The time required for a breaker to open after receiving a signal from the trip unit to operate. The combination of the Trip/Delay time and the Breaker Opening time determines the total time required to clear the fault. For low-voltage circuit breakers, the total clearing time displayed on the Manufacturer's drawing is assumed to include the breaker opening time.
- Ground: Indicates whether the fault location includes a path to ground. Systems with high-resistance grounds are assumed to be ungrounded in the Arc Flash calculations. (Available for IEEE 1584 only)
- Equip Type: Used only in the IEEE 1584 method to indicate whether the equipment is Switchgear, Panel, Cable or Open Air. The equipment type provides a default Gap value and a distance exponent used in the IEEE incident energy equations. The equipment type provides a default Gap value and a distance exponent used in the IEEE incident energy equations.
- Gap: Used only in the IEEE 1584 method to define the spacing between bus bars or conductors at the arc location.
- Duration of Arc: The summation of Trip/Delay Time and Breaker Opening Time.
- Arc Type: Identifies whether the fault location is in an enclosure or in open air. In open air the arc energy will radiate in all directions whereas an enclosure will focus the energy toward the enclosure opening. The In Box / Air selection is available when the NFPA 70E study option is selected. For the IEEE 1584 study selection the In Box or In Air is determined automatically from the Equipment Type specification.
- Arc Flash Boundary: The distance from exposed live parts within which a person could receive a 2nd degree burn.
- Working Distance: The distance between the arc source and the worker's face or chest.
- Incident Energy: The amount of energy on a surface at a specific distance from a flash.
- Required Protective FR Clothing Category (PPE): Indicates the PPE required preventing an incurable burn at the working distance during an arcing fault.
- Label #: This allows the user to specify the prefix character that will go on the "Label #" column in the Arc Flash spreadsheet report. This field can help in sorting out (organizing) the label when they printed out.
- Cable Length from Trip Device: Reports the total cable length from the protective device that trips to clear the fault to the faulted bus. If there is no cable in between, nothing will be reported.

The results from the arc flash analysis show four main categories of concern. The first category is a Category 0. This category incorporates most of the components within the system, and has an upper limit of 1.2 cal/cm2 for the incident energy. The proper clothing and equipment for this category, as well as all other categories, is described in the PPE Table on page 18. The second category is a Category 1, which has an incident energy range of 1.2 – 4 cal/cm2. The third category that shows up in the arc flash analysis report for this system is Category 2. Category 2 has an incident energy range of 4 – 8 cal/cm2. Categories 0 – 4 require a Warning label with the appropriate arc flash information listed to be placed on the equipment. Finally, the last category that is present in this system is a category of Danger. This category is the most severe category, and requires a DANGER label to be placed on the equipment stating that live work is not to be performed. The incident energy range for the Danger category is 40 – 999 cal/cm2.

Table 11. Arc-flash personal protective equipment information.

Hazard Risk Category	Incident Energy From (cal/cm2)	Incident Energy To (cal/cm2)	IE Low Marginal (cal/cm^2)	IE High Marginal (cal/cm^2)	Clothing Description	Clothing Layers	Required Minimum Arc Rating of PPE (cal/cm2)	Notes	Category Background Color	Category Foreground Color	Warning Label Text	Head & Eye & Hearing Protection	Hand & Arm Protection	Foot Protection	PPE Others 1	PPE Others 2	PPE Others 3	PPE Others 4
0	0	1.2	0	1.19	Untreated Cotton	1	N/A				**WARNING**	Hardhat + Polycarbonate Face Shield + Safety Glasses	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	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).
1	1.2	4	1.21	3.9	FR Shirt & Pants	1	4				**WARNING**	Hardhat + Polycarbonate Face Shield + Safety Glasses	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield.	4 cal/sq cm, FR shirt (long-sleeve) plus FR pants (long), or FR coverall, 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).
2	4	8	4.1	7.8	Cotton Underwear + FR Shirt & Pants	1 or 2	8				**WARNING**	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	8 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).
3	8	25	8.2	24	Cotton Underwear + FR Shirt & Pants + FR Coverall	2 or 3	25				**WARNING**	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	25 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).
4	25	40	26	38	Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	3 or more	40				**WARNING**	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	40 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).
Dangerous!	40	999	41	998	No FR Category Found	Do not work on live!	N/A	Do not work on live!			**DANGER**	Do not work on live!	Do not work on live!	Do not work on live!	No FR Category Found	Arc Flash Incident Energy Exceeds the Rating of Category 4 PPE.	No FR Category Found	No FR Category Found

Table 12. Arc-flash analysis results.

Bus Name	Bus kV	Bus Bolted Fault (kA)	Bus Arcing Fault (kA)	Prot Dev Bolted Fault (kA)	Prot Dev Arcing Fault (kA)	Trip/ Delay Time (sec.)	Breaker Opening Time (sec.)	Ground	Equip Type	Gap (mm)	Arc Flash Boundary (in)	Working Distance (in)	Incident Energy (cal/cm2)	Required Protective FR Clothing Category	Label #	Cable Length From Trip Device (ft)	Incident Energy at Low Marginal	Incident Energy at High Marginal
BUS-0002	12.47	4.89	4.80	4.61	4.53	0.021	0.000	Yes	SWG	153	3	36	0.12	Category 0	# 0003			
BUS-0002	12.47	4.89	4.80	0.28	0.28	0.083	0.000	Yes	SWG	153	3	36	0.14	Category 0		15.00		
MCC1 BUS (Motor Control Center 1)	0.48	28.50	16.04	28.48	16.03	0.004	0.000	No	PNL	25	8	18	0.30	Category 0	# 0046	12.00		
MCC1 BUS (Motor Control Center 1)	0.48	28.50	16.04	0.01	0.01	0.083	0.000	No	PNL	25	8	18	0.30	Category 0				
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	24.55	14.08	0.004	0.000	No	PNL	25	7	18	0.26	Category 0	# 0047	20.00		
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	0.01	0.01	0.083	0.000	No	PNL	25	9	18	0.39	Category 0				
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	0.02	0.01	0.083	0.000	No	PNL	25	9	18	0.39	Category 0				
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	0.35	0.20	0.083	0.000	No	PNL	25	9	18	0.39	Category 0				
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	0.04	0.02	0.083	0.000	No	PNL	25	9	18	0.39	Category 0				
MCC2A BUS (Motor Control Center 2A)	0.48	24.99	14.34	0.04	0.02	0.083	0.000	No	PNL	25	9	18	0.39	Category 0				
MCC2B BUS (Motor Control Center 2B)	0.48	25.02	14.36	23.98	13.76	0.008	0.000	No	PNL	25	11	18	0.53	Category 0	# 0048	27.00		
MCC2B BUS (Motor Control Center 2B)	0.48	25.02	14.36	1.05	0.60	0.083	0.000	No	PNL	25	14	18	0.79	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	27.07	15.17	0.008	0.000	No	PNL	25	12	18	0.62	Category 0	# 0049	8.00		
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	1.75	0.98	0.016	0.000	No	PNL	25	13	18	0.67	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.01	0.01	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.42	0.24	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.01	0.00	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.04	0.02	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.07	0.04	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4A BUS (Motor Control Center 4A)	0.48	29.39	16.47	0.04	0.02	0.083	0.000	No	PNL	25	14	18	0.80	Category 0				
MCC4B BUS	0.48	28.89	16.23	27.15	15.25	0.004	0.000	No	PNL	25	8	18	0.30	Category 0	# 0050	12.00		
MCC4B BUS	0.48	28.89	16.23	1.75	0.99	0.083	0.000	No	PNL	25	13	18	0.74	Category 0				
PTS BUS	0.48	21.21	12.46	21.01	12.35	0.004	0.000	No	PNL	25	7	18	0.23	Category 0	# 0051	30.00		
PTS BUS	0.48	21.21	12.46	0.21	0.12	0.083	0.000	No	PNL	25	8	18	0.29	Category 0				
PTS BUS	0.48	21.21	12.46	0.02	0.01	0.083	0.000	No	PNL	25	8	18	0.29	Category 0				
MCC1 1-P PB BUS	0.208	0.96	0.84	0.96	0.84	1.101	0.000	Yes	PNL	25	18	18	1.2	Category 0 (*N15)	# 0012			1.20
MCC2 1-P PB BUS	0.208	0.96	0.84	0.96	0.84	1.102	0.000	Yes	PNL	25	18	18	1.2	Category 0 (*N15)	# 0023			1.20
MCC4 1-P PB BUS (Motor Control Center 4B)	0.208	0.96	0.84	0.96	0.84	1.101	0.000	Yes	PNL	25	18	18	1.2	Category 0 (*N15)	# 0034			1.20
BUS-0001	12.47	4.91	4.82	0.28	0.28	0.083	0.000	Yes	SWG	153	11	36	0.49	Category 0 (*N2) (*N5)		135.00		
Dryer Control BUS	0.48	16.98	10.31	16.22	9.85	0.06	0.000	No	PNL	25	29	18	2.7	Category 1	# 0011	140.00		
Dryer Control BUS	0.48	16.98	10.31	0.01	0.01	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
Dryer Control BUS	0.48	16.98	10.31	0.02	0.01	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
Dryer Control BUS	0.48	16.98	10.31	0.53	0.32	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
Dryer Control BUS	0.48	16.98	10.31	0.06	0.03	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
Dryer Control BUS	0.48	16.98	10.31	0.22	0.13	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
Dryer Control BUS	0.48	16.98	10.31	0.04	0.02	0.083	0.000	No	PNL	25	30	18	2.7	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	26.90	14.09	0.06	0.000	No	SWG	32	42	24	2.7	Category 1	# 0022	100.00		
MCC1/QED SB BUS	0.48	30.07	15.75	0.04	0.02	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	0.04	0.02	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	0.04	0.02	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	0.23	0.12	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	0.01	0.01	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	0.04	0.02	0.083	0.000	No	SWG	32	43	24	2.8	Category 1				
MCC1/QED SB BUS	0.48	30.07	15.75	2.80	1.47	0.083	0.000	No	SWG	32	43	24	2.8	Category 1		20.00		
VMCC BUS (Vermeer Motor Control Enclosure)	0.48	27.96	13.42	25.17	12.07	0.06	0.000	No	PNL	25	35	18	3.5	Category 1 (*N3) (*N5)	# 0057	100.00		
BUS-0039	0.48	34.40	16.01	9.52	5.21	0.083	0.000	No	PNL	25	53	18	7.1	Category 2		15.00		
MCC2/QED SB BUS (MCC2/QED Switchboard)	0.48	27.73	15.67	26.21	14.81	0.06	0.000	No	PNL	25	39	18	4.2	Category 2	# 0033	100.00		
MCC2/QED SB BUS (MCC2/QED Switchboard)	0.48	27.73	15.67	0.01	0.01	0.083	0.000	No	PNL	25	39	18	4.3	Category 2				
MCC2/QED SB BUS (MCC2/QED Switchboard)	0.48	27.73	15.67	0.01	0.01	0.083	0.000	No	PNL	25	39	18	4.3	Category 2				
MCC2/QED SB BUS (MCC2/QED Switchboard)	0.48	27.73	15.67	0.46	0.26	0.083	0.000	No	PNL	25	39	18	4.3	Category 2				
MCC2/QED SB BUS (MCC2/QED Switchboard)	0.48	27.73	15.67	1.05	0.59	0.083	0.000	No	PNL	25	39	18	4.3	Category 2				
MCC4/QED SB BUS (MCC4/QED Switchboard)	0.48	30.32	16.91	26.22	14.63	0.06	0.000	No	PNL	25	41	18	4.6	Category 2	# 0045	100.00		
MCC4/QED SB BUS (MCC4/QED Switchboard)	0.48	30.32	16.91	0.04	0.02	0.083	0.000	No	PNL	25	42	18	4.8	Category 2				
MCC4/QED SB BUS (MCC4/QED Switchboard)	0.48	30.32	16.91	2.34	1.30	0.083	0.000	No	PNL	25	42	18	4.8	Category 2				
MCC4/QED SB BUS (MCC4/QED Switchboard)	0.48	30.32	16.91	1.75	0.98	0.083	0.000	No	PNL	25	42	18	4.8	Category 2				
QED MAIN SWITCHGEAR	0.48	34.24	15.95	1.51	0.83	0.083	0.000	No	PNL	25	53	18	7.1	Category 2				
QED MAIN SWITCHGEAR	0.48	34.24	15.95	0.85	0.47	0.083	0.000	No	PNL	25	53	18	7.1	Category 2				
QED MAIN SWITCHGEAR	0.48	34.24	15.95	4.04	2.21	0.083	0.000	No	PNL	25	53	18	7.1	Category 2				
QED MAIN SWITCHGEAR	0.48	34.24	15.95	2.76	1.51	0.083	0.000	No	PNL	25	53	18	7.1	Category 2 (*N5)		20.00		
BUS-0001	12.47	4.91	4.82	4.63	4.55	1000	0.000	Yes	SWG	153	209105	36	5493	Dangerous! (*N2) (*N9)	# 0001			
BUS-0039	0.48	34.40	16.01	24.88	11.58	8.333	0.000	No	PNL	25	663	18	444	Dangerous! (*N3)	# 0010			
QED MAIN SWITCHGEAR	0.48	34.24	15.95	24.70	11.51	0.847	0.000	No	PNL	25	167	18	46	Dangerous! (*N3)	# 0056			
Category 0: Untreated Cotton													#Cat 0 = 10	(*N2) < 80% Cleared Fault Threshold				
Category 1: FR Shirt & Pants													#Cat 1 = 3	(*N3) - Arcing Current Low Tolerances Used				
Category 2: Cotton Underwear + FR Shirt & Pants													#Cat 2 = 2	(*N5) - Miscoordinated, Upstream Device Tripped				
Category 3: Cotton Underwear + FR Shirt & Pant + FR Coverall													#Cat 3 = 0	(*N9) - Max Arcing Duration Reached				
Category 4: Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit													#Cat 4 = 0	(*N15) - Report as category 0 if fed by one transformer size < 125 kVA				
Category Dangerous!: No FR Category Found													#Danger = 3	IEEE 1584 - 2002/2004a Edition Bus Report (80% Cleared Fault Threshold, include Ind. Motors for 5.0 Cycles), mis-coordination				

4. Ground Review

As part of the BioMass PDU project analysis, grounding and multi-state code reviews were performed. The 480V system has been considered in the review process and has been checked against three possible system configurations, a four-wire grounded system, a four-wire high-impedance system, and a three-wire delta system. As part of this review, it was suggested that the equipment grounding system and the static/lightning protections systems be integrated into one ground-wire system.

The system will have loads delta connected; this includes motors, step-down transformers, and variable-speed drives. Given the three possible system configurations, there are different code sections to which they must adhere.

For the four-wire grounded system, {§250.20(B)(2)} of the National Electric Code must be followed, explaining a neutral grounded system. The neutral conductor must be run to each subpanel that is listed as a four-wire panel.

For a four-wire high-impedance grounded system, {§250.20(E)} of the National Electric Code must be followed, specifically explaining the neutral high-impedance grounded system.

For a three-wire delta system, {§250.20(D); §250.21(A)(4)} of the National Electric Code must be followed for an ungrounded system. It is specifically noted that the panels must be listed and rated for an ungrounded delta system.

The size of the grounding electrode conductor where supplied by a feeder or branch circuit or at a separately derived system of a grounded or an ungrounded alternating current system shall not be less than given in Table 250.66, except as permitted in 250.66(A) – (C) of the NEC.

Figure 4 represents the grounded system as applied to the BioMass PDU application.

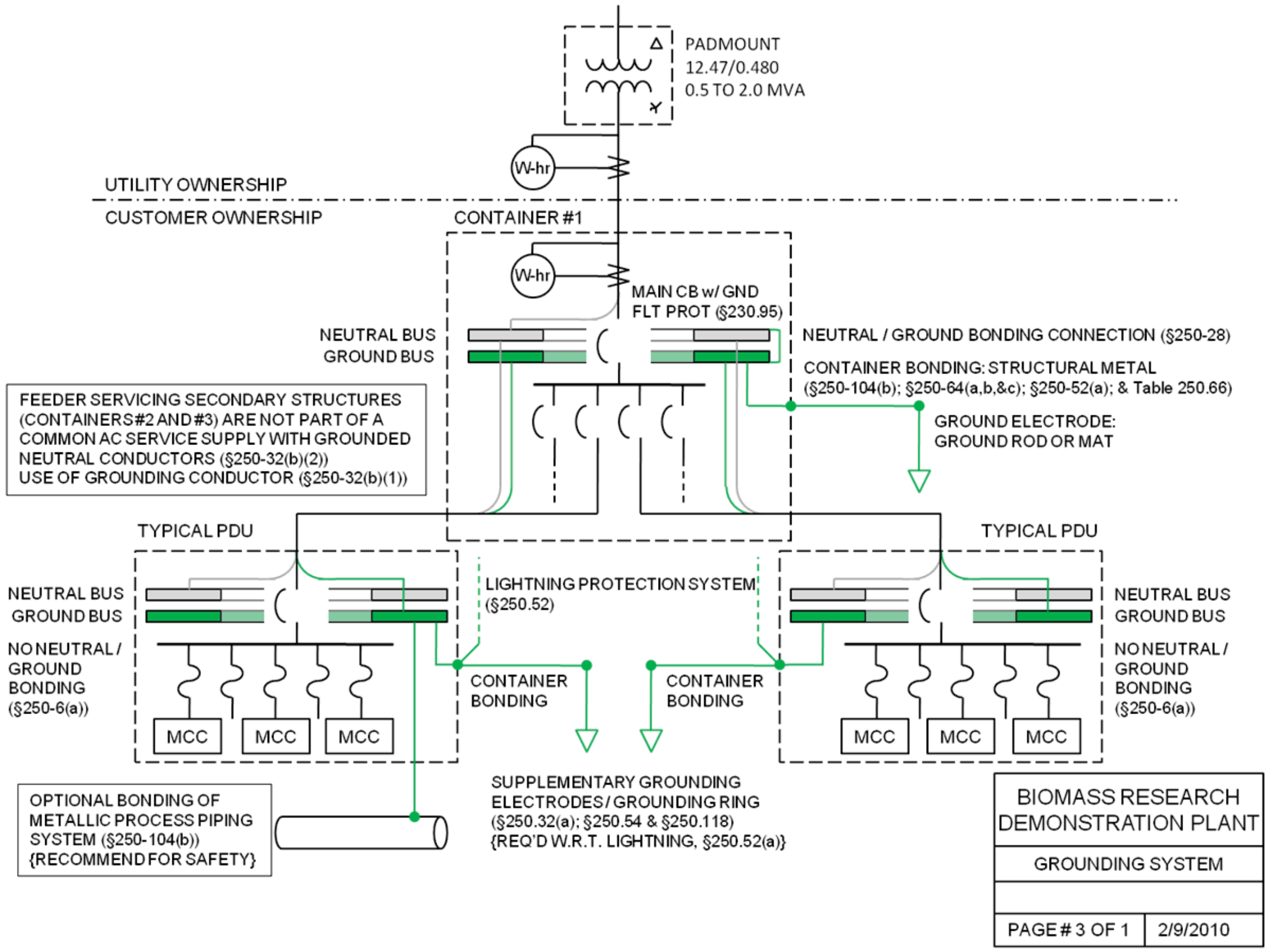

Figure 4. Biomass PDU grounding description.

5. Multi-State Code Review

The BioMass PDU project will not be a permanent unit. It will be a mobile unit that could spend time in any state across the nation. This changes the typical standards review that most electrical projects go through. The fact that multiple states could be involved requires the review of every state's electric code requirements for such a unit. The major concern for the multi-state code review was directed toward the review of Code Section 250 in the National Electric Code. This section describes the Grounding and Bonding requirements.

A few comment definitions as they apply to the BioMass PDU project are as follows:

- Standard Application—The code is applied in a standard fashion as with any project. Material selection or implementation choices are at the discretion of the project manager.
- Specifically Applied—The project must address or implement this particular part of the code.
- N/A—Generally, not applicable to this project as it has been defined.

The following table shows the sections of Article 250 and how they relate to the BioMass PDU project as defined.

Section	Comment	Section	Comment	Section	Comment
250.3		250.30	Standard application	250.80-86	Standard application
250.4(A)	Applicable	250.34	n/a	250.90-98	Standard application
250.4(B)	n/a	250.36	Applicable for Hi-Z	250.100	Specifically applies
250.6	Standard application	250.50	Standard application	250.102-104	Standard application
250.8	Standard application	250.52	Specifically applies	250.106	Specifically applies
250.10	Standard application	250.53	Standard application	250.110-112	Standard application
250.12	Standard application	250.54	Specifically applies	250.114-119	Specifically applies
250.20	Permissible configurations: (B)(2); (D)(see 250.30) or (E)	250.60	Specifically applies	250.120	Standard application
250.21	Applicable for UG (A)(4)	250.62	Standard application	250.122-124	Specifically applies
250.22	n/a	250.64	Standard application	250.130-148	Standard application
250.24	Applicable, especially (A)(2)	250.66	Specifically applies	250.170-176	n/a
250.26	Applicable: (3) only	250.68	Specifically applies	250.170-176	n/a
250.28	Use Table 250.66	250.70	Standard application	250.180-186	n/a

Figure 5. 2008 NEC code review for Article 250.

The following map is from the National Electric Manufacturers Association (NEMA) and is intended to provide information on the current adoptions of the NEC to local jurisdictions. It is intended to be used by the project manager to ensure that the installation meets local code requirements.

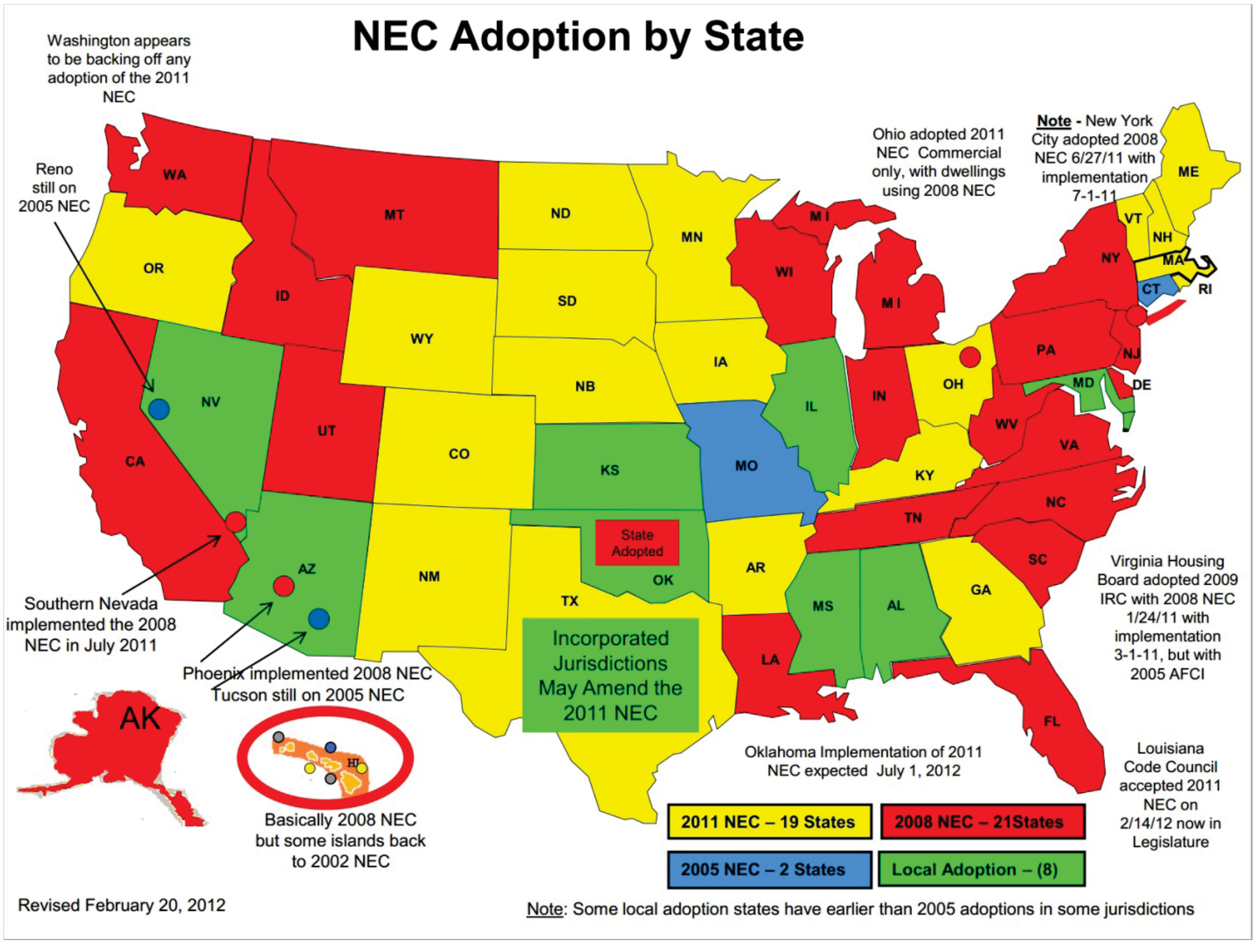

Figure 6. 2011 NEC adoptions by state.

Appendix A

Input Data

Conductors

[NOTE: Ctrl+click on the image to open the PDF file.]

BRANCH NAME	FROM NAME	TO NAME	TYPE	Phase	VD%	AMPS	KVA	RATING%
Utility Underground	BUS-0001	BUS-0002	FDR	(A)	0.02	72.47	516.38	48.32
				(B)	0.03	84.5	601.1	56.34
				(C)	0.02	79.55	565.33	53.03
Utility Supplied	BUS-0002	BUS-0039	TX3	(A)	3.09	72.47	516.25	90.74
				(B)	11.73	84.5	600.93	105.81
				(C)	5.48	79.55	565.2	99.6
MCC1 Feeder Cable	QED MAIN SWITCHGEAR	MCC1/QED SB BUS	FDR	(A)	0.3	566.76	160.18	40.2
				(B)	0.35	660.23	159.14	46.82
				(C)	0.33	621.88	160.53	44.1
MCC2 Feeder Cable	QED MAIN SWITCHGEAR	MCC2/QED SB BUS	FDR	(A)	0.32	400.02	113.05	42.55
				(B)	0.36	460.68	111.04	49.01
				(C)	0.36	443.06	114.37	47.13
Dryer Feeder Cable	QED MAIN SWITCHGEAR	Dryer Control	FDR	(A)	0.55	146.58	41.42	63.73
				(B)	0.65	172.32	41.54	74.92
				(C)	0.6	160.69	41.48	69.87
MCC4 Feeder Cable	QED MAIN SWITCHGEAR	MCC4/QED SB BUS	FDR	(A)	0.41	769.43	217.45	54.57
				(B)	0.49	902.15	217.45	63.98
				(C)	0.45	841.01	217.1	59.65
Main Feeder Cable	BUS-0039	QED MAIN SWITCHGEAR	FDR	(A)	0.06	1882.78	532.4	66.06
				(B)	0.07	2195.35	529.57	77.03
				(C)	0.06	2066.62	533.84	72.51
MCC2 CBL1	MCC2/QED SB BUS	BUS-0009	FDR	(A)	0.17	15.77	4.44	45.05
				(B)	0.2	18.52	4.44	52.9
				(C)	0.19	17.28	4.44	49.37
MCC2 CBL2	MCC2/QED SB BUS	BUS-0010	FDR	(A)	0.02	1.78	0.5	5.09
				(B)	0.02	2.09	0.5	5.97
				(C)	0.02	1.95	0.5	5.57
MCC2 CBL3	MCC2/QED SB BUS	BUS-0043	FDR	(A)	0.03	2.37	0.67	6.78
				(B)	0.03	2.79	0.67	7.96
				(C)	0.03	2.6	0.67	7.43
MCC2 CBL4	MCC2/QED SB BUS	BUS-0012	FDR	(A)	0.16	78.82	22.21	68.54
				(B)	0.19	92.57	22.22	80.49
				(C)	0.18	86.38	22.21	75.12
MCC2 CBL5	MCC2/QED SB BUS	MCC2A BUS	FDR	(A)	0.04	77.55	21.85	33.72
				(B)	0.05	91.22	21.89	39.66
				(C)	0.05	85.06	21.87	36.98
MCC2 CBL6	MCC2/QED SB BUS	MCC2B BUS	FDR	(A)	0.09	197.32	55.59	51.93
				(B)	0.09	222.5	53.41	58.55
				(C)	0.1	220.88	56.8	58.13
MCC2 CBL7	MCC2/QED SB BUS	BUS-0015	FDR	(A)	0.17	15.77	4.44	45.05
				(B)	0.2	18.52	4.44	52.9
				(C)	0.19	17.28	4.44	49.37
MCC2 CBL8	MCC2/QED SB BUS	BUS-0069	FDR	(A)	0.21	10.65	3	42.59
				(B)	0.25	12.51	3	50.02
				(C)	0.23	11.67	3	46.68
MCC4 CBL1	MCC4/QED SB BUS	BUS-0018	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL2	MCC4/QED SB BUS	BUS-0019	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL5	MCC4/QED SB BUS	MCC4A BUS	FDR	(A)	0.05	396.33	111.56	104.3
				(B)	0.06	465.83	111.66	122.59
				(C)	0.06	434.43	111.61	114.32
MCC4 CBL6	MCC4/QED SB BUS	MCC4B BUS	FDR	(A)	0.06	306.41	86.25	80.63
				(B)	0.07	357.95	85.8	94.2
				(C)	0.06	333.48	85.67	87.76
MCC4 CBL7	MCC4/QED SB BUS	BUS-0024	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL8	MCC4/QED SB BUS	BUS-0025	FDR	(A)	0.17	13.41	3.78	38.32
				(B)	0.2	15.76	3.78	45.03
				(C)	0.18	14.7	3.78	42
Dryer CBL1	Dryer Control	BUS-0070	FDR	(A)	0.03	2.02	0.57	8.1
				(B)	0.04	2.38	0.57	9.51
				(C)	0.04	2.22	0.57	8.88
Dryer CBL2	Dryer Control	BUS-0071	FDR	(A)	0.04	2.55	0.72	10.22
				(B)	0.05	3	0.72	12
				(C)	0.05	2.8	0.72	11.2
Dryer CBL3	Dryer Control	BUS-0072	FDR	(A)	0.15	89.31	25.1	68.7
				(B)	0.18	105	25.12	80.77
				(C)	0.16	97.91	25.11	75.32
Dryer CBL4	Dryer Control	BUS-0073	FDR	(A)	0.16	9.49	2.67	37.98
				(B)	0.19	11.16	2.67	44.65
				(C)	0.17	10.41	2.67	41.64
Dryer CBL5	Dryer Control	BUS-0074	FDR	(A)	0.17	36.44	10.24	56.06
				(B)	0.21	42.84	10.25	65.91
				(C)	0.19	39.95	10.25	61.46
MCC1 CBL1	MCC1/QED SB BUS	BUS-0052	FDR	(A)	0.06	5.94	1.67	16.96

Transformer

[NOTE: Ctrl+click on the image to open the PDF file.]

2-Winding Transformer	Phase	(kW)	(kVAR)	PctVD(%)
Utility Supplied XFRMR	A:	426.3	318.9	3.09
	B:	423.9	317.4	11.73
	C:	425.5	322.4	5.48
MCC1 Dist XFRMR	A:	1.9	1.4	5.26
	B:	1.6	1.2	2.69
	C:	3.2	2.3	0.39
MCC2 Dist XFRMR	A:	4.1	3.1	7.79
	B:	1.7	1.2	2.81
	C:	5.5	4	2.42
MCC4 Dist XFRMR	A:	1.8	1.3	5.1
	B:	1.6	1.2	2.65
	C:	1.6	1.2	2.24

Utility

[NOTE: Ctrl+click on the image to open the PDF file.]

Utility	Phase	(kW)	(kVAR)	PctVD(%)
Utility	A	411.19	312.35	1.03
	B	481.34	360.05	1.2
	C	403.1	396.38	1.29

Loads

[NOTE: Ctrl+click on the image to open the PDF file.]

General Load	Phase	(kW)	(kVAR)	PctVD(%)	LF Current (A)
Leveling Jacks	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Metering Bin MC	A:	17.7	13.3	0.16	78.8
	B:	17.7	13.3	0.19	92.6
	C:	17.7	13.3	0.18	86.4
Screw Conveyor Control SC-4	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Screw Conveyor Control SC-5	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Screw Conveyor Control SC-6	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
Densification Module Heaters	A:	3.5	2.7	0.17	15.8
	B:	3.5	2.7	0.2	18.5
	C:	3.5	2.7	0.19	17.3
MCC4 Bard A/C Unit	A:	3	2.3	0.17	13.4
	B:	3	2.3	0.2	15.8
	C:	3	2.3	0.18	14.7
MCC1 Bard A/C Unit	A:	3.1	2.3	0.18	13.8
	B:	2.3	1.7	0.14	11.8
	C:	2.6	1.9	0.15	12.6
MCC2 Bard A/C Unit	A:	2.4	1.8	0.21	10.6
	B:	2.4	1.8	0.25	12.5
	C:	2.4	1.8	0.23	11.7
CC1R-J13 Light Circuit	A:	0.2	0.2	0.07	2.3
	B:	0	0	0	0
	C:	0	0	0	0
MCC1 Receptacle	A:	0.1	0.1	0.02	1.2
	B:	0	0	0	0
	C:	0	0	0	0
MCC1 Dryer Module	A:	1.5	1.2	2.68	17.1
	B:	0	0	0	0
	C:	0	0	0	0
MCC1 Dryer Module0	A:	0	0	0	0
	B:	0	0	0	0
	C:	1.5	1.2	2.78	17.7
Decomp Module	A:	0	0	0	0
	B:	0	0	0	0
	C:	1.5	1.2	1.36	17.4
Decomp Module0	A:	0	0	0	0
	B:	1.5	1.2	1.52	19.4
	C:	0	0	0	0
CC21-J11 Light Circuit	A:	0.2	0.2	0.07	2.3
	B:	0	0	0	0
	C:	0	0	0	0
Milling Module	A:	1.5	1.2	0.54	17.2
	B:	0	0	0	0
	C:	0	0	0	0
Milling Module0	A:	0	0	0	0
	B:	0	0	0	0
	C:	1.5	1.2	0.56	17.8
MCC2 Receptacle	A:	0	0	0	0
	B:	0.1	0.1	0.04	1.4
	C:	0	0	0	0
Metering Bin	A:	0	0	0	0
	B:	0	0	0	0
	C:	1.5	1.2	0.56	17.8
Metering Bin0	A:	0	0	0	0
	B:	1.5	1.2	0.6	19.3
	C:	0	0	0	0
CC4L-J11	A:	0.2	0.2	0.07	2.3
	B:	0	0	0	0
	C:	0	0	0	0
Densification Module Lights	A:	0	0	0	0
	B:	0	0	0	0
	C:	1.5	1.2	0.53	17
Densification Module Lights0	A:	0	0	0	0
	B:	1.5	1.2	0.6	19.2
	C:	0	0	0	0
Densification Module I&C	A:	1.5	1.2	0.52	16.7
	B:	0	0	0	0
	C:	0	0	0	0
Control Trailer	A:	2.3	1.7	1.16	25.9
	B:	0	0	0	0
	C:	2.3	1.7	1.06	26.9

Motors

[NOTE: Ctrl+click on the image to open the PDF file.]

Induction Motor	Phase	(kW)	(kVAR)	PctVD(%)	LF Current (A)	(hp)
Bucket Elevator OBE-2	A:	0.4	0.3	0.02	1.8	1.5
	B:	0.4	0.3	0.02	2.1	
	C:	0.4	0.3	0.02	2	
Drag Conveyor DC-7	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Belt Conveyor BC-1	A:	0.5	0.4	0.03	2.4	2
	B:	0.5	0.4	0.03	2.8	
	C:	0.5	0.4	0.03	2.6	
Drag Conveyor DC-8	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Drag Conveyor DC-6	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Drag Conveyor DC-9	A:	1.3	1	0.06	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Inlet Airlock	A:	0.5	0.3	0.03	2	1.5
	B:	0.5	0.3	0.04	2.4	
	C:	0.5	0.3	0.04	2.2	
Outlet Airlock	A:	0.6	0.4	0.04	2.6	1.5
	B:	0.6	0.4	0.05	3	
	C:	0.6	0.4	0.05	2.8	
Main Fan	A:	20.1	15	0.15	89.3	75
	B:	20.1	15	0.18	105	
	C:	20.1	15	0.16	97.9	
Drum Drive	A:	2.1	1.6	0.16	9.5	7.5
	B:	2.1	1.6	0.19	11.2	
	C:	2.1	1.6	0.17	10.4	
Combustion Blower	A:	8.2	6.1	0.17	36.4	25
	B:	8.2	6.1	0.21	42.8	
	C:	8.2	6.1	0.19	40	
Fire Supression System	A:	1.5	1.1	0.11	6.8	5
	B:	1.5	1.1	0.13	7.9	
	C:	1.5	1.1	0.12	7.4	
Drag Conveyor DC-5	A:	0.5	0.4	0.03	2.4	2
	B:	0.5	0.4	0.03	2.8	
	C:	0.5	0.4	0.03	2.6	
PTS Blower	A:	0.8	0.6	0.04	3.6	3
	B:	0.8	0.6	0.05	4.2	
	C:	0.8	0.6	0.04	3.9	
PTS Motor	A:	8	6	0.11	35.7	30
	B:	8	6	0.13	41.9	
	C:	8	6	0.12	39.1	
Vermeer In-Feed Motor	A:	0.4	0.3	0.01	1.8	1.5
	B:	0.4	0.3	0.02	2.1	
	C:	0.4	0.3	0.02	2	
Vermeer Grinder HG-1A	A:	53.5	40.1	0.24	238.1	200
	B:	53.5	40.1	0.28	279.9	
	C:	53.5	40.1	0.26	261.1	
Vermeer Grinder HG-1B	A:	53.5	40.1	0.24	238.1	200
	B:	53.5	40.1	0.28	279.9	
	C:	53.5	40.1	0.26	261.1	
Bag House Pulsar BH-1A	A:	0.8	0.6	0.03	3.6	3
	B:	0.8	0.6	0.04	4.2	
	C:	0.8	0.6	0.03	3.9	
Screw Conveyor 1 SC-1	A:	1.3	1	0.05	5.9	5
	B:	1.3	1	0.06	7	
	C:	1.3	1	0.05	6.5	
Screw Conveyor 2 SC-2	A:	1.3	1	0.05	5.9	5
	B:	1.3	1	0.06	7	
	C:	1.3	1	0.05	6.5	
Air Lock AL-1	A:	0.5	0.4	0.02	2.4	2
	B:	0.5	0.4	0.02	2.8	
	C:	0.5	0.4	0.02	2.6	
Plenum Blower PB-1	A:	13.4	10	0.66	59.7	50
	B:	13.4	10	0.79	70.3	
	C:	13.4	10	0.73	65.5	
Hammermill G-2	A:	40.1	30.1	0.24	178.5	150
	B:	40.1	30.1	0.28	209.8	
	C:	40.1	30.1	0.26	195.7	
Air Lock AL-2	A:	0.5	0.4	0.02	2.4	2
	B:	0.5	0.4	0.02	2.8	
	C:	0.5	0.4	0.02	2.6	
Drag Conveyor DC-1	A:	1.3	1	0.05	5.9	5
	B:	1.3	1	0.06	7	
	C:	1.3	1	0.05	6.5	
Rotating Feeder CRF-1	A:	0.3	0.2	0.01	1.2	1
	B:	0.3	0.2	0.01	1.4	
	C:	0.3	0.2	0.01	1.3	
Pellet Mill Conditioner PMC-1	A:	2.7	2	0.04	11.9	10
	B:	2.7	2	0.05	14	
	C:	2.7	2	0.05	13	
Blower B-2	A:	16	12	0.05	71.3	60
	B:	16	12	0.06	83.8	
	C:	16	12	0.06	78.2	
Air Compressor	A:	1.3	1	0.07	5.9	5
	B:	1.3	1	0.08	7	
	C:	1.3	1	0.07	6.5	
Pellet Mill PM-2	A:	66.8	50.1	0.23	297.7	250
	B:	66.8	50.1	0.27	349.9	
	C:	66.8	50.1	0.25	326.3	
Screw Conveyor SC-3	A:	1.3	1	0	5.9	5
	B:	1.3	1	0	7	
	C:	1.3	1	0	6.5	
Pellet Mill PM-1	A:	66.8	50.1	0.23	297.7	250
	B:	66.8	50.1	0.27	350	
	C:	66.8	50.1	0.25	326.3	

Breakers

[NOTE: Ctrl+click on the image to open the PDF file.]

LV Breakers	Description	Type	Frame/Sensor/Plug	SETTINGS
Main SwitchGear	SQUARE D	RK	2500.0A	LTPU/LTD (A 0.4-1.0 x S) 1 (2500A); 0.5
	Powerpact R-Frame, 6.0A/P/H		2500.0A	STPU (1.5-10 x LTPU) 5 (12500A)
	LSI, 600-2500A, UL			STD (0-0.4) 0.1 (I^2t Out)
	SQUARE D	RK	2500.0A	INST (2-15 x S) 6 (15000A)
	Powerpact R-Frame, 6.0A/P/H		2500.0A	GFPU (500-1200A) J (1200A)
	GF, 1600-2500AS, UL			GFD (0-0.4) 0.4 (I^2t In)
Main SGB1	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB2	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB3	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Main SGB4	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
MCC1 Main	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
MCC2 Main	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Dryer Main	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
MCC4 Main	SQUARE D	PJ	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.9 (900A); 1
	Powerpact P-Frame, 6.0A/P/H		1000.0A	STPU (1.5-10 x LTPU) 10 (9000A)
	LSI, 100-1200A, UL			STD (0-0.4) 0.4 (I^2t In)
	SQUARE D	PK	1200.0A	INST (2-15 x S) 6 (6000A)
	Powerpact P-Frame, 6.0A/P/H		600.0A	GFPU (0.2-1.0 x S) D (300A)
	GF, 600-1200AS, UL			GFD (0-0.4) 0.2 (I^2t In)
Dryer Breaker1	SQUARE D	HJ	15.0A	Fixed
	HJ		15.0A	
	15-150A			
Dryer Breaker2	SQUARE D	HJ	15.0A	Fixed
	HJ		15.0A	
	15-150A			
Dryer Breaker3	SQUARE D	HJ	125.0A	Fixed
	HJ		125.0A	
	15-150A			
Dryer Breaker4	SQUARE D	HJ	20.0A	Fixed
	HJ		20.0A	
	15-150A			
Dryer Breaker5	SQUARE D	HJ	70.0A	Fixed
	HJ		70.0A	
	15-150A			
Dryer Breaker6	SQUARE D	HJ	15.0A	Fixed
	HJ		15.0A	
	15-150A			
MCC1 VMCC	SQUARE D	PG	1200.0A	LTPU/LTD (A 0.4-1.0 x S) 0.4 (320A); 4
	Powerpact P-Frame, 6.0A/P/H		800.0A	STPU (1.5-10 x LTPU) 10 (3200A)
	LSI, 100-1200A, UL			STD (0-0.4) 0 (I^2t In)
	SQUARE D	PG	1200.0A	INST (2-15 x S) 15 (12000A)

Fuses

[NOTE: Ctrl+click on the image to open the PDF file.]

Fuses	Description	FRAME/MODEL	Cartridge/Trip
Utility Fuse	SQUARE D	CS-3, 100E	100.0A
	CS-3, 15.5kV E-Rated		100.0A
	10E-100E		
MCC1 Fuse 1	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 2	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 3	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 4	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC1 Fuse 5	BUSSMANN	JKS	400.0A
	JKS, 600V Class J		400.0A
	1-600A		
MCC1 Fuse 6	BUSSMANN	JKS	400.0A
	JKS, 600V Class J		400.0A
	1-600A		
MCC1 Fuse 7	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 8	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC1 Fuse 9	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC1 PTS Fuse 1	BUSSMANN	LPJ-60SP	60.0A
	LPJ_SP, 600V Class J		60.0A
	15-600A		
MCC1 PTS Fuse 2	BUSSMANN	LPJ-30SP	30.0A
	LPJ_SP, 600V Class J		30.0A
	15-600A		
MCC2 Fuse 1	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC2 Fuse 2	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC2 Fuse 3	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC2 Fuse 4	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC2 Fuse 5	BUSSMANN	JKS	200.0A
	JKS, 600V Class J		200.0A
	1-600A		
MCC2 Fuse 6	BUSSMANN	JKS	600.0A
	JKS, 600V Class J		450.0A
	1-600A		
MCC2 Fuse 7	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC2 Fuse 8	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC2 Fuse 9	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A
	1-600A		
MCC4 Fuse 1	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC4 Fuse 2	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC4 Fuse 3	BUSSMANN	JKS	30.0A
	JKS, 600V Class J		30.0A
	1-600A		
MCC4 Fuse 4	BUSSMANN	JKS	100.0A
	JKS, 600V Class J		100.0A

Appendix B

Short Circuit Analysis

[NOTE: Ctrl+click on the image to open the PDF file.]

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THREE PHASE FAULT REPORT
  (FOR APPLICATION OF LOW VOLTAGE BREAKERS)
     PRE FAULT VOLTAGE: 1.0000
     MODEL TRANSFORMER TAPS: NO
======================================================================

BUS-0001     3P Duty:  4.910 KA AT  -85.95 DEG ( 106.06 MVA)  X/R:    14.55
        VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1035 + J  1.4625  OHMS
        CONTRIBUTIONS:  UTIL-0001        4.630 KA      ANG:   -86.19
        Utility Underg  BUS-0002         0.281 KA      ANG:  -262.13

BUS-0002     3P Duty:  4.889 KA AT  -85.10 DEG ( 105.60 MVA)  X/R:    11.83
        VOLTAGE:  12470.   EQUIV. IMPEDANCE=  0.1258 + J  1.4671  OHMS
        Utility Underg  BUS-0001         4.608 KA      ANG:   -85.28
        Utility Suppli  BUS-0039         0.281 KA      ANG:  -262.18

BUS-0039     3P Duty: 34.397 KA AT  -81.57 DEG (  28.60 MVA)  X/R:     6.82
        VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0012 + J  0.0080  OHMS
        LOW VOLTAGE POWER CIRCUIT BREAKER   34.611 KA
        MOLDED CASE CIRCUIT BREAKER > 20KA  36.748 KA
        Utility Suppli  BUS-0002        24.879 KA      ANG:  -261.08
        Main Feeder Ca  QED MAIN SWITC    9.521 KA      ANG:   -82.85

Dryer Control  3P Duty: 16.982 KA AT  -55.23 DEG (  14.12 MVA)  X/R:     1.69
        VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0093 + J  0.0134  OHMS
        LOW VOLTAGE POWER CIRCUIT BREAKER   16.982 KA
        MOLDED CASE CIRCUIT BREAKER < 20KA  16.982 KA
        MOLDED CASE CIRCUIT BREAKER > 20KA  16.982 KA
        Dryer CBL2     BUS-0071         0.015 KA      ANG:    95.89
        Dryer CBL3     BUS-0072         0.530 KA      ANG:    96.22
        Dryer CBL4     BUS-0073         0.056 KA      ANG:    96.36
        Dryer CBL5     BUS-0074         0.216 KA      ANG:    96.39
        Dryer CBL6     BUS-0075         0.040 KA      ANG:    96.17
        Dryer CBL1     BUS-0070         0.012 KA      ANG:    95.85
        Dryer Feeder C  QED MAIN SWITC   16.223 KA      ANG:   -53.77

MCC1 1-P PB BU 3P Duty:  0.957 KA AT  -27.30 DEG (   0.34 MVA)  X/R:     0.52
        VOLTAGE:    208.   EQUIV. IMPEDANCE=  0.1115 + J  0.0575  OHMS
        LOW VOLTAGE POWER CIRCUIT BREAKER    0.957 KA
        MOLDED CASE CIRCUIT BREAKER < 10KA   0.957 KA
        MOLDED CASE CIRCUIT BREAKER < 20KA   0.957 KA
        MOLDED CASE CIRCUIT BREAKER > 20KA   0.957 KA
        MCC1 Dist Xfrm  MCC1 BUS         0.957 KA      ANG:   152.70

MCC1 BUS      3P Duty: 28.496 KA AT  -76.59 DEG (  23.69 MVA)  X/R:     4.36
        VOLTAGE:    480.   EQUIV. IMPEDANCE=  0.0023 + J  0.0095  OHMS
```

Appendix C

Load Flow Analysis

[NOTE: Ctrl+click on the image to open the PDF file.]

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ALL INFORMATION PRESENTED IS FOR REVIEW, APPROVAL
INTERPRETATION AND APPLICATION BY A REGISTERED ENGINEER ONLY
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SKM POWER*TOOLS FOR WINDOWS
LOAD FLOW AND VOLTAGE DROP ANALYSIS REPORT
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*** SOLUTION COMMENTS ***

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SOLUTION PARAMETERS

BRANCH VOLTAGE CRITERIA : 3.00 %
BUS VOLTAGE CRITERIA : 5.00 %

UTILITY IMPEDANCE : YES
TRANSFORMER PHASE SHIFT : NO
LTC TRANSFORMER : NO
CALCULATION NETHOD : Newton Method
SOLUTION METHOD : EXACT
ALL PU VALUES ARE EXPRESSED ON A 100 MVA BASE
LOAD FLOW IS BASED ON CONNECTED LOADS.
LOAD ANALYSIS INCLUDES ALL LOADS.
<<PERCENT VOLTAGE DROPS ARE BASED ON NOMINAL DESIGN VOLTAGES>>

SWING GENERATORS

SOURCE NAME	VOLTAGE	ANGLE
UTIL-0001	1.000	0.00

Load Flow BUS Information

[NOTE: Ctrl+click on the image to open the PDF file.]

BUS NAME	System Voltage	(%) VD A	(%) VD B	(%) VD C	LF Voltage (V) A	LF Voltage (V) B	LF Voltage (V) C
BUS-0001	12470	1.03	1.2	1.29	7125	7113	7107
BUS-0002	12470	1.06	1.23	1.31	7123	7111	7105
BUS-0009	480	-1.49	13.59	7.4	281	239	257
BUS-0010	480	-1.64	13.41	7.23	282	240	257
BUS-0012	480	-1.5	13.58	7.39	281	240	257
BUS-0015	480	-1.49	13.59	7.4	281	239	257
BUS-0018	480	-1.4	13.71	7.48	281	239	256
BUS-0019	480	-1.4	13.71	7.48	281	239	256
BUS-0024	480	-1.4	13.71	7.48	281	239	256
BUS-0025	480	-1.4	13.7	7.48	281	239	256
BUS-0029	480	-1.61	13.45	7.25	282	240	257
BUS-0039	480	-2.03	12.96	6.79	283	241	258
BUS-0043	480	-1.63	13.42	7.24	282	240	257
BUS-0048	480	-1.61	13.45	7.25	282	240	257
BUS-0052	480	-1.61	13.45	7.25	282	240	257
BUS-0053	480	-1.61	13.45	7.25	282	240	257
BUS-0064	480	-1.5	13.52	7.34	281	240	257
BUS-0069	480	-1.45	13.63	7.44	281	239	257
BUS-0070	480	-1.4	13.71	7.49	281	239	256
BUS-0071	480	-1.39	13.72	7.5	281	239	256
BUS-0072	480	-1.28	13.85	7.62	281	239	256
BUS-0073	480	-1.27	13.86	7.63	281	239	256
BUS-0074	480	-1.26	13.88	7.65	281	239	256
BUS-0075	480	-1.32	13.81	7.58	281	239	256
BUS-0087	480	-1.65	13.41	7.22	282	240	257
BUS-0088	208	3.65	100	100	116	0	0
BUS-0090	208	3.6	100	100	116	0	0
BUS-0091	208	6.26	100	100	113	0	0
BUS-0094	208	100	100	9.58	0	0	109
BUS-0095	208	100	100	8.16	0	0	110
BUS-0096	208	100	17.59	100	0	99	0
BUS-0098	480	-1.56	13.52	7.32	281	240	257
BUS-0099	480	-1.49	13.6	7.4	281	239	257
BUS-0100	480	-1.51	13.57	7.37	281	240	257
BUS-0101	480	100	100	100	0	0	0
BUS-0102	480	-1.29	13.84	7.61	281	239	256
BUS-0103	480	-1.29	13.84	7.61	281	239	256
BUS-0105	480	-1.59	13.47	7.29	282	240	257
BUS-0106	480	-1.57	13.49	7.31	281	240	257
BUS-0107	480	-1.57	13.49	7.31	281	240	257
BUS-0108	480	-1.6	13.46	7.28	282	240	257
BUS-0109	480	-0.96	14.22	7.99	280	238	255
BUS-0110	480	-1.35	13.76	7.57	281	239	256
BUS-0111	208	6.29	100	100	113	0	0
BUS-0112	208	6.75	100	100	112	0	0
BUS-0113	208	100	100	10.29	0	0	108
BUS-0114	208	100	16.33	100	0	100	0
BUS-0116	208	100	100	10.29	0	0	108
BUS-0117	208	100	16.89	100	0	100	0
BUS-0119	480	-1.5	13.59	7.38	281	239	257
BUS-0120	480	-1.47	13.63	7.41	281	239	257
BUS-0121	480	-1.51	13.58	7.36	281	239	257
BUS-0122	480	-1.47	13.62	7.4	281	239	257
BUS-0123	480	-1.46	13.63	7.41	281	239	257
BUS-0124	480	-1.5	13.59	7.37	281	239	257
BUS-0125	480	-1.29	13.84	7.6	281	239	256
BUS-0126	480	-1.52	13.57	7.36	281	240	257
BUS-0127	480	-1.28	13.85	7.61	281	239	256
BUS-0128	208	3.66	100	100	116	0	0
BUS-0129	208	100	100	5.66	0	0	113
BUS-0130	208	100	16.83	100	0	100	0
BUS-0131	208	4.11	100	100	115	0	0
BUS-0132	208	100	100	100	0	0	0
BUS-0133	208	100	100	100	0	0	0
BUS-0134	208	100	100	100	0	0	0
BUS-0135	208	100	100	100	0	0	0
BUS-0136	208	100	100	100	0	0	0
BUS-0139	208	100	100	100	0	0	0
BUS-0140	480	100	100	100	0	0	0
BUS-0141	480	100	100	100	0	0	0
BUS-0142	480	100	100	100	0	0	0
BUS-0143	208	100	100	100	0	0	0
BUS-0144	208	100	100	100	0	0	0
BUS-0145	208	100	100	100	0	0	0
BUS-0146	208	100	100	100	0	0	0
BUS-0147	208	100	100	100	0	0	0
BUS-0148	208	100	100	100	0	0	0
BUS-0150	480	100	100	100	0	0	0
BUS-0151	208	7.38	100	10.79	111	0	107
BUS-0153	208	100	100	100	0	0	0
Dryer Control BUS	480	-1.43	13.67	7.45	281	239	256
MCC1 1-P PB BUS	208	3.58	16.07	6.8	116	101	112
MCC1 BUS	480	-1.68	13.38	7.19	282	240	257
MCC1/QED SB BUS	480	-1.68	13.38	7.18	282	240	257
MCC2 1-P PB BUS	208	6.21	16.29	9.73	113	101	108
MCC2/QED SB BUS	480	-1.66	13.39	7.21	282	240	257
MCC2A BUS	480	-1.62	13.44	7.26	282	240	257
MCC2B BUS	480	-1.57	13.48	7.31	282	240	257
MCC4 1-P PB BUS	208	3.59	16.23	5.13	116	101	114
MCC4/QED SB BUS	480	-1.57	13.51	7.3	281	240	257
MCC4A BUS	480	-1.52	13.57	7.35	281	240	257
MCC4B BUS	480	-1.51	13.58	7.36	281	240	257
PTS BUS	480	-1.6	13.47	7.27	282	240	257
QED MAIN SWITCHGEAR	480	-1.98	13.02	6.85	283	241	258
VMCC BUS	480	-1.52	13.56	7.35	281	240	257

Load Flow Conductor Information

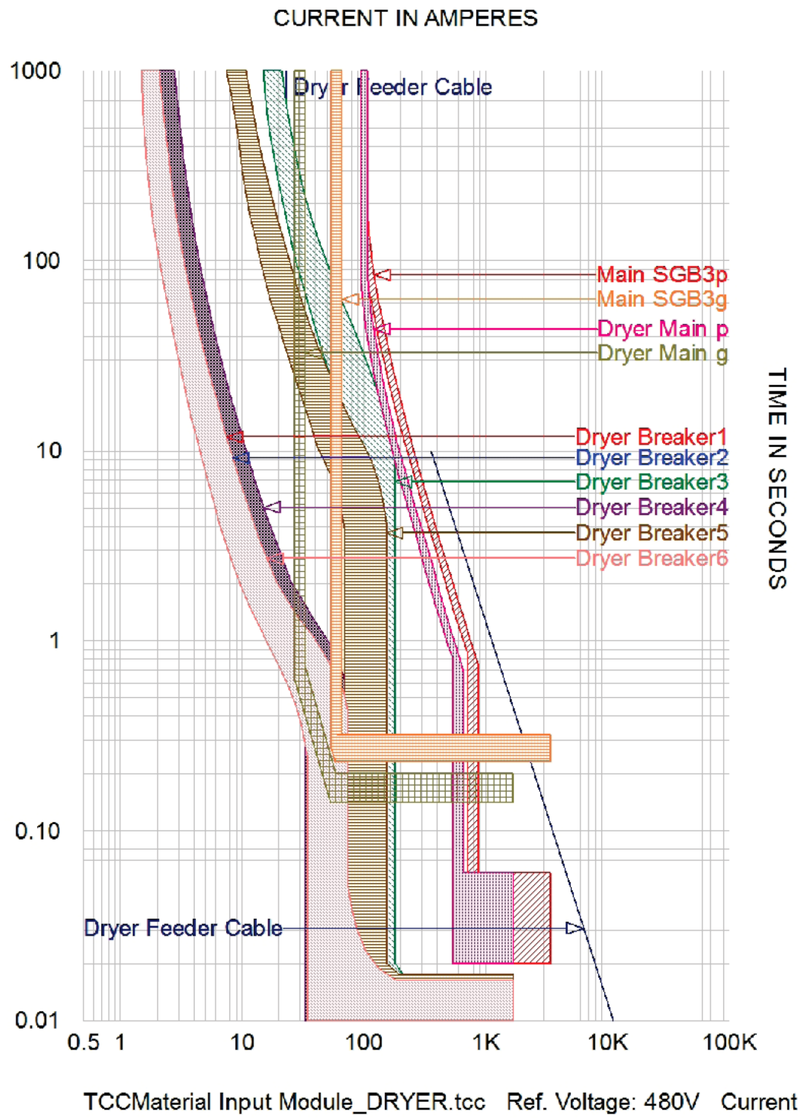
[NOTE: Ctrl+click on the image to open the PDF file.]

BRANCH NAME	FROM NAME	TO NAME	TYPE	Phase	VD%	AMPS	KVA	RATING%
Utility Underground	BUS-0001	BUS-0002	FDR	(A)	0.02	72.47	516.38	48.32
				(B)	0.03	84.5	601.1	56.34
				(C)	0.02	79.55	565.33	53.03
Utility Supplied	BUS-0002	BUS-0039	TX3	(A)	3.09	72.47	516.25	90.74
				(B)	11.73	84.5	600.93	105.81
				(C)	5.48	79.55	565.2	99.6
MCC1 Feeder Cable	QED MAIN SWITCHGEAR	MCC1/QED SB BUS	FDR	(A)	0.3	566.76	160.18	40.2
				(B)	0.35	660.23	159.14	46.82
				(C)	0.33	621.88	160.53	44.1
MCC2 Feeder Cable	QED MAIN SWITCHGEAR	MCC2/QED SB BUS	FDR	(A)	0.32	400.02	113.05	42.55
				(B)	0.36	460.68	111.04	49.01
				(C)	0.36	443.06	114.37	47.13
Dryer Feeder Cable	QED MAIN SWITCHGEAR	Dryer Control	FDR	(A)	0.55	146.58	41.42	63.73
				(B)	0.65	172.32	41.54	74.92
				(C)	0.6	160.69	41.48	69.87
MCC4 Feeder Cable	QED MAIN SWITCHGEAR	MCC4/QED SB BUS	FDR	(A)	0.41	769.43	217.45	54.57
				(B)	0.49	902.15	217.45	63.98
				(C)	0.45	841.01	217.1	59.65
Main Feeder Cable	BUS-0039	QED MAIN SWITCHGEAR	FDR	(A)	0.06	1882.78	532.4	66.06
				(B)	0.07	2195.35	529.57	77.03
				(C)	0.06	2066.62	533.84	72.51
MCC2 CBL1	MCC2/QED SB BUS	BUS-0009	FDR	(A)	0.17	15.77	4.44	45.05
				(B)	0.2	18.52	4.44	52.9
				(C)	0.19	17.28	4.44	49.37
MCC2 CBL2	MCC2/QED SB BUS	BUS-0010	FDR	(A)	0.02	1.78	0.5	5.09
				(B)	0.02	2.09	0.5	5.97
				(C)	0.02	1.95	0.5	5.57
MCC2 CBL3	MCC2/QED SB BUS	BUS-0043	FDR	(A)	0.03	2.37	0.67	6.78
				(B)	0.03	2.79	0.67	7.96
				(C)	0.03	2.6	0.67	7.43
MCC2 CBL4	MCC2/QED SB BUS	BUS-0012	FDR	(A)	0.16	78.82	22.21	68.54
				(B)	0.19	92.57	22.22	80.49
				(C)	0.18	86.38	22.21	75.12
MCC2 CBL5	MCC2/QED SB BUS	MCC2A BUS	FDR	(A)	0.04	77.55	21.85	33.72
				(B)	0.05	91.22	21.89	39.66
				(C)	0.05	85.06	21.87	36.98
MCC2 CBL6	MCC2/QED SB BUS	MCC2B BUS	FDR	(A)	0.09	197.32	55.59	51.93
				(B)	0.09	222.5	53.41	58.55
				(C)	0.1	220.88	56.8	58.13
MCC2 CBL7	MCC2/QED SB BUS	BUS-0015	FDR	(A)	0.17	15.77	4.44	45.05
				(B)	0.2	18.52	4.44	52.9
				(C)	0.19	17.28	4.44	49.37
MCC2 CBL8	MCC2/QED SB BUS	BUS-0069	FDR	(A)	0.21	10.65	3	42.59
				(B)	0.25	12.51	3	50.02
				(C)	0.23	11.67	3	46.68
MCC4 CBL1	MCC4/QED SB BUS	BUS-0018	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL2	MCC4/QED SB BUS	BUS-0019	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL5	MCC4/QED SB BUS	MCC4A BUS	FDR	(A)	0.05	396.33	111.56	104.3
				(B)	0.06	465.83	111.66	122.59
				(C)	0.06	434.43	111.61	114.32
MCC4 CBL6	MCC4/QED SB BUS	MCC4B BUS	FDR	(A)	0.06	306.41	86.25	80.63
				(B)	0.07	357.95	85.8	94.2
				(C)	0.06	333.48	85.67	87.76
MCC4 CBL7	MCC4/QED SB BUS	BUS-0024	FDR	(A)	0.17	15.78	4.44	45.09
				(B)	0.2	18.54	4.44	52.98
				(C)	0.19	17.3	4.44	49.41
MCC4 CBL8	MCC4/QED SB BUS	BUS-0025	FDR	(A)	0.17	13.41	3.78	38.32
				(B)	0.2	15.76	3.78	45.03
				(C)	0.18	14.7	3.78	42
Dryer CBL1	Dryer Control	BUS-0070	FDR	(A)	0.03	2.02	0.57	8.1
				(B)	0.04	2.38	0.57	9.51
				(C)	0.04	2.22	0.57	8.88
Dryer CBL2	Dryer Control	BUS-0071	FDR	(A)	0.04	2.55	0.72	10.22
				(B)	0.05	3	0.72	12
				(C)	0.05	2.8	0.72	11.2
Dryer CBL3	Dryer Control	BUS-0072	FDR	(A)	0.15	89.31	25.1	68.7
				(B)	0.18	105	25.12	80.77
				(C)	0.16	97.91	25.11	75.32
Dryer CBL4	Dryer Control	BUS-0073	FDR	(A)	0.16	9.49	2.67	37.98
				(B)	0.19	11.16	2.67	44.65
				(C)	0.17	10.41	2.67	41.64
Dryer CBL5	Dryer Control	BUS-0074	FDR	(A)	0.17	36.44	10.24	56.06
				(B)	0.21	42.84	10.25	65.91
				(C)	0.19	39.95	10.25	61.46
MCC1 CBL1	MCC1/QED SB BUS	BUS-0052	FDR	(A)	0.06	5.94	1.67	16.96

Appendix D

TCC Drawings (MCC1, MCC2, Dryer, MCC4)

[NOTE: Ctrl+click on the image to open the PDF file.]



Appendix E

Arc Flash Documents

[NOTE: Ctrl+click on the image to open the PDF file.]

	Incident Energy From (cal/cm2)	Incident Energy To (cal/cm2)	IE Low Marginal (cal/cm^2)	IE High Marginal (cal/cm^2)	Hazard Risk Category	Clothing Description	Clothing Layers	Required Minimum Arc Rating of PPE (cal/cm2)	Notes	Category Background Color	Category Foreground Color
1	0.0	1.2	0.000	1.190	0	Untreated Cotton	1	N/A			
2	1.2	4.0	1.210	3.900	1	FR Shirt & Pants	1	4			
3	4.0	8.0	4.100	7.800	2	Cotton Underwear + FR Shirt & Pants	1 or 2	8			
4	8.0	25.0	8.200	24.000	3	Cotton Underwear + FR Shirt & Pant + FR Coverall	2 or 3	25			
5	25.0	40.0	26.000	38.000	4	Cotton Underwear + FR Shirt & Pant + Multi Layer Flash Suit	3 or more	40			
6	40.0	999.0	41.000	998.000	Dangerous!	No FR Category Found	Do not work on live!	N/A	Do not work on live!		

	Warning Label Text	Head & Eye & Hearing Protection	Hand & Arm Protection	Foot Protection	PPE Others 1	PPE Others 2	PPE Others 3	PPE Others 4	PPE Others 5
1	WARNING	Hardhat + Polycarbonate Face Shield + Safety Glasses	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	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).	
2	WARNING	Hardhat + Polycarbonate Face Shield + Safety Glasses	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield.	4 cal/sq cm, FR shirt (long-sleeve) plus FR pants (long), or FR coverall, 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).	
3	WARNING	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	8 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).	
4	WARNING	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	25 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).	
5	WARNING	Hardhat + Polycarbonate Face Shield + Safety Glasses + Ear Canal Inserts	Voltage Rated Electrical Gloves	Rubber Soled Leather Boots	Safety glasses, electrically rated hard hat with hood and face shield. Hearing protection.	40 cal/sq cm, cotton underwear T-shirt and briefs or shorts, FR shirt (long-sleeve) plus FR pants (long), or FR coverall/coat, 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).	
6	DANGER	Do not work on live!	Do not work on live!	Do not work on live!	No FR Category Found	Arc Flash Incident Energy Exceeds the Rating of Category 4 PPE.	No FR Category Found	No FR Category Found	

Appendix F

Equipment Evaluation Reports

[NOTE: Ctrl+click on the image to open the PDF file.]

	A	B	C	D	E	F	G	H	I	J	K
1	Device	Status	Bus	Bus	Rated	VD%	LF	Design	Ampacity	LF%	Design%
2				Volts	Volts		Amps	Amps			
3	MCC1 CBL21	Fail	VMCC BUS	480	600	0.26	*259.23	*301.51	230.0	*112.71	*131.09
4	MCC1 CBL22	Fail	VMCC BUS	480	600	0.26	*259.23	*301.51	230.0	*112.71	*131.09
5	MCC1 CBL5	Fail	MCC1/QED SB BUS	480	600	0.17	*520.40	*544.53	380.0	*136.95	*143.30
6	MCC2 CBL27	Fail	MCC2A BUS	480	600	0.73	*65.07	*75.38	50.0	*130.14	*150.76
7											
8	MCC4 CBL48	Fail	MCC4A BUS	480	600	0.25	*324.01	*376.89	310.0	*104.52	*121.58
9	MCC4 CBL5	Fail	MCC4/QED SB BUS	480	600	0.06	*431.36	*476.99	380.0	*113.52	*125.52
10	MCC4 CBL50	Fail	MCC4B BUS	480	600	0.25	*324.04	*376.89	310.0	*104.53	*121.58
11	MCC4 CBL6	Fail	MCC4/QED SB BUS	480	600	0.06	332.18	*384.42	380.0	87.42	*101.16
12											
13	MCC1 Dist Xfmr1 (Pri)	Fail *(P,S)	MCC1 BUS	480	*480	*3.70	*14.92	*11.25	10.8	*137.83	*103.90
14	MCC2 Dist Xfmr0 (Pri)	Fail *(P,S)	MCC2B BUS	480	*480	*6.62	*27.79	*21.46	10.8	*256.69	*198.24
15	Utility Supplied XFMR (Pr	Fail *(P,S)	BUS-0002	12470	12470	*4.91	*79.14	*76.31	79.9	*99.09	*95.55
16	CC2I-J11 Lighting Circuit	Fail	BUS-0111	208	*208	*11.54	2.49				
17											
18	Control Trailer	Fail	BUS-0151	208	*208	*14.35	28.02				
19	Decomp Module	Fail	BUS-0095	208	*208	*11.65	18.11				
20	Dryer Module	Fail	BUS-0091	208	*208	*11.51	18.08				
21	Dryer Module0	Fail	BUS-0094	208	*208	*13.12	18.42				
22											
23	Metering Bin	Fail	BUS-0116	208	*208	*13.86	18.57				
24	Milling Module	Fail	BUS-0112	208	*208	*12.03	18.19				
25	Milling Module0	Fail	BUS-0113	208	*208	*13.86	18.57				
26											
27	(*Device Voltage) Device did not pass. Device is either Marginal (100%) or Failed (100%) of the device voltage rating.										
28	(*LF Amps) Device did not pass. Device is either Marginal (90%) or Failed (100%) of the continuous current ampacity.										
29	(*Design Amps) Device did not pass. Device is either Marginal (90%) or Failed (100%) of the continuous current ampacity.										

Appendix G

Electrical Inspection Emails

[NOTE: Ctrl+click on the image to open the PDF file.]

Electrical Inspection visit 1:

Jason,

No apology needed, I believe I was on the hook to provide you with a note to include a summary of last week's findings and mine and Ken's availability to complete the inspection. It has been an equally busy week for me.

Overall, most of the equipment that we were able to inspect appears to be installed in accordance with the requirements of the National Electrical Code. Below are the items identified so far that will need to be addressed to make some of the individual pieces of equipment code compliant.

1) Several of the control panel enclosures need bonding jumpers added to the branch circuit equipment grounding conductor(s). A bond should also be added to the door (if conductive metal) of any panel that has energized components mounted to the door.

2) All of the non-NRTL industrial control panels will need an NEC 409.110 compliant label. Note that the SCCR is not applicable to the panels that contain only control circuit components (Ref: 409.110(4) Exception), which will simplify this requirement for some of your panels.

3) In one panel we observed a small heater that was not secured. This condition and any similar should be corrected.

Jake and Jason, a few recommendations for the model:

1) Assigning names to the buses and other individual pieces of equipment on the model that reflect the actual equipment name or equipment ID will make the model easier to follow and maintain.

2) As previously discussed, adding the breaker/fuse detail for the branch circuits feeding the individual motors will also enhance the usability of the model.

3) Don't hesitate to use text blocks to describe specific assumptions/conditions/unknowns/status/etc. of the model or of the individual components.

The available times next week for both Ken and I are, in priority:

Tuesday
Wednesday afternoon
Thursday

The focus will be on one or two of the main MCC containers and the details of one copy each of the unlisted control panels. For the control panels, I would like to borrow the schematics and cut sheets for the individual components from Rod sometime before the inspection. We should be able to complete the inspections in a half day if the equipment is de-energized.

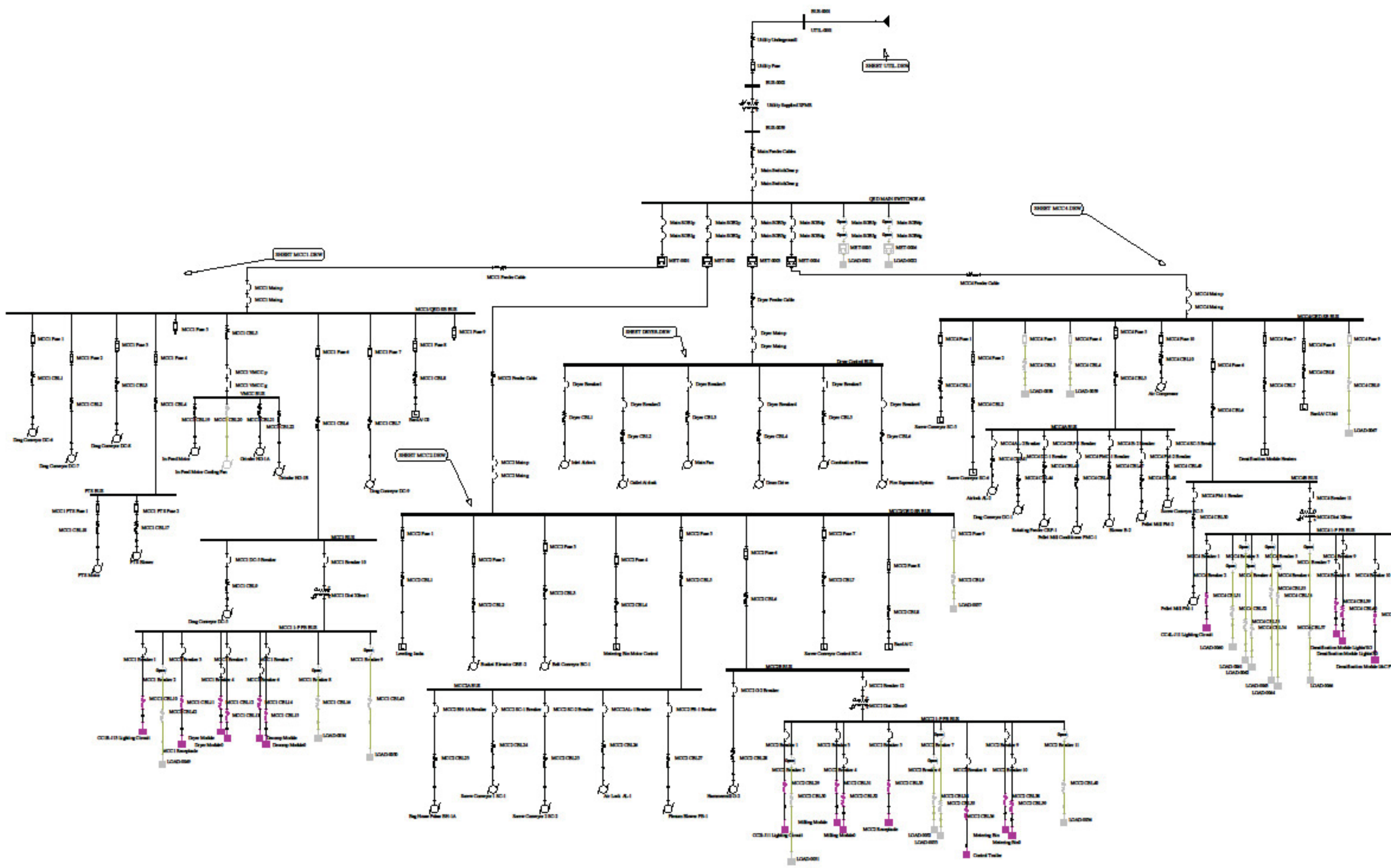
Thanks,

John

Appendix H

Simple One-Line Drawings

[NOTE: Ctrl+click on the image to open the PDF file.]



Appendix I

CAD ANSI A_Fault One-Line Drawings

[NOTE: Ctrl+click on the image to open the PDF file.]