Final Report

Susquehanna Center Renovations & Expansion

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April 7, 2011

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Electrical Depth – Branch Circuit Redesign

Space Descriptions:

The electrical redesigns of four spaces are the same four spaces, in which a lighting redesign was done. Those four spaces are the Auxiliary Gymnasium, Fitness and Weight Room, Main Lobby, and Main Entry Façade. The lobby is the primary circulation space that has hallways that branch off of it that will lead you to the adjacent Fitness and Weight room. The weight room is a typical fitness facility with all types of workout equipment available to students and athletes on the Harford Community College's campus. One of those branching hallways also leads to the Auxiliary Gymnasium, which is your standard full size basketball court with two smaller perpendicular courts.

The lighting redesign consisted mostly of replacing fluorescent troffers with fluorescent down-lights, wall washers, and other accent lighting hardware. All lighting in the Susquehanna Center is operated using 277 volts.

Panel Boards Affected

Panel Tag	Voltage	System	Exterior Façade	Main Lobby	Fitness and Weight Room	Auxiliary Gym
LPA	480Y/277V, 3P, 4W	N			**X**	**X**
LPB	480Y/277V, 3P, 4W	N		**X**		
SITE	480Y/277V, 3P, 4W	N	**X**			

Table 20. Panelboards Affected by Lighting Redesign

NOTE: The individual circuits that have been affected are highlighted in the following Panels with their respected colors.

Control Information and Space Layout

Auxiliary Gymnasium

The controls in the space will be primarily used to accommodate the daylight harvesting system that utilizes multiple Lutron products. The primary piece of equipment will be the photocell located in the center of the space that will relay information to the automated day-lighting control via a Lutron Grafik Eye. This Grafik Eye specializes in the utilization of daylight harvesting and will control the light output of the high bay fluorescent luminaires that provide general illumination. All luminaires in this space will be supplied with 277V and controlled by another Grafik Eye, which will be located in the main electric room. Emergency luminaires will have an emergency ballast controlled by both the Grafik Eye and Emergency Relay to switch the luminaire from normal power to emergency power. A new dimming Panel DP was introduced for this space, so that the luminaires could be dimmed. The panel is feed by Panel LPA and located in the Electric. See drawings for exact location.

Fitness and Weight Room

In this space the control system is simplistic in nature. The control system is comprised of a combination of vacancy sensors with wall switches. Wall switches will be the primary controller of the lights, but the vacancy sensor will provide the automatic shut-off requirements for ASHRAE 90.1. Emergency luminaires will have an emergency ballast controlled by both the wall switch and an emergency relay that will switch the luminaire from normal power to emergency power.

Main Lobby

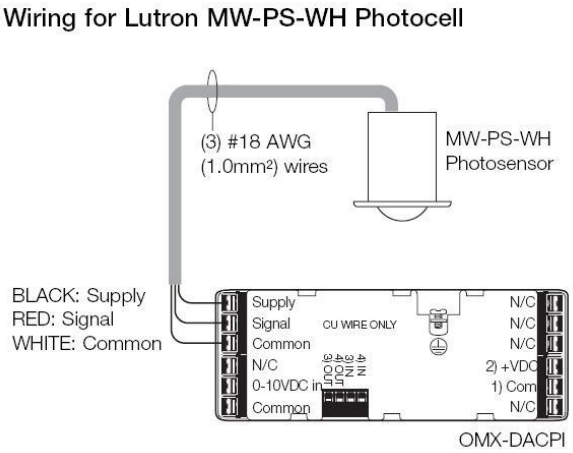
Since this space is a circulation space the lighting will be controlled by an astronomical time clock. Emergency luminaires will have an emergency ballast controlled by both the astronomical time clock and an emergency relay that will switch the luminaire from normal power to emergency power.

Main Entry Façade

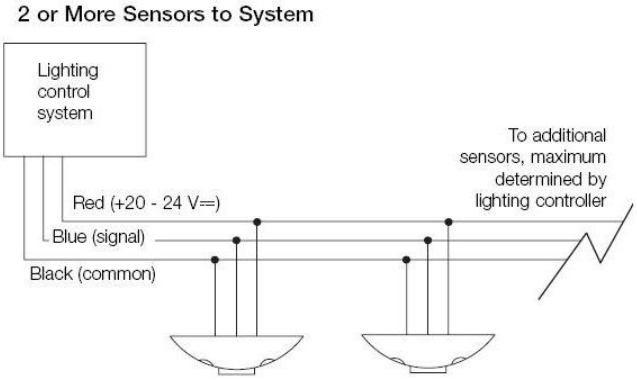
This space will be controlled via an astronomical time clock because it is located outside.

NOTE: See the following drawings in order above for Electrical Plans.

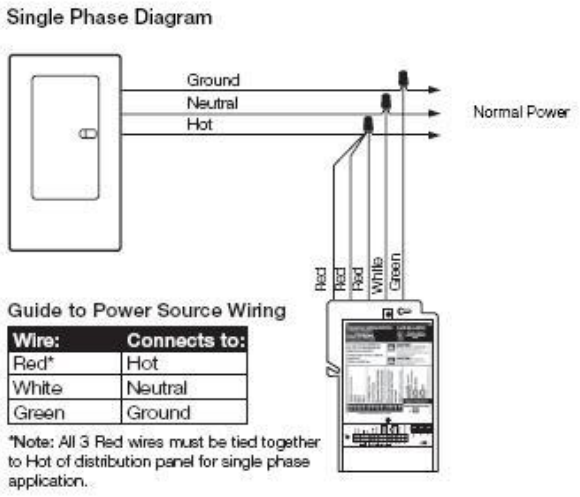
Control Wiring Diagrams



Drawing 19. Wiring Diagram of Photocell



Drawing 20. Wiring Diagram of Vacancy Sensors



Drawing 21. Wiring Diagram of Lighting Relay

Existing Panelboards and Modified Circuits

PANEL LPA — **MAIN: 225A MCB** — **VOLTAGE: 480Y/ 277 3 PH 4 W**
AIC: 35,000 — **MOUNTING: SURFACE** — **NOTE:**
LOCATION: MAIN ELECT. RM. 157 — **100% RATED NEUTRAL BUS**

CKT	EQUIPMENT SERVED	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	BREAKER P	BREAKER AMPS	BREAKER P	BREAKER AMPS	LOAD (KVA) A	LOAD (KVA) B	LOAD (KVA) C	EQUIPMENT SERVED	CKT
1	L: 137, 38, 57-59 N TOILETS	2.3			1	20	1	20	1.7			L: FITNESS	2
3	L: CORRI 150		2.1		1	20	1	20		2.8		L: FITNESS & OFFICES	4
5	L: CORRI 152			1.7	1	20	1	20			1.3	L: FITNESS DL	6
7	L: CORRI 152 & 56	2.7			1	20	1	20				L: FITNESS COVE	8
9	L: 148		1.5		1	20	1	20		2.8		L: MULTI #1 & 2	10
11	L: AUX GYM			3.6	1	20	1	20				L: 142A, 43-45, 49 & 51	12
13	L: AUX GYM	3.6			1	20	1	20	0.4			L: EXT. BY SAIL	14
15	L: 114		0.8		1	20	1	20		3.2		L: NE OFFICES	16
17	SPARE				1	20	1	20			2.8	L: 109, 112 & 113	18
19	SPARE				1	20	1	20				SPARE	20
21	SPACE				-	-	-	-				SPACE	22
23	SPACE				-	-	-	-				SPACE	24
25	SPACE				-	-	-	-				SPACE	26
27	SPACE				-	-	-	-				SPACE	28
29	SPACE				-	-	-	-				SPACE	30
31	SPACE				-	-	-	-				SPACE	32
33	SPACE				-	-	-	-				SPACE	34
35	SPACE				-	-	-	-				SPACE	36
37	PANEL 'RPA' TRANSFORMER	25.9			3	125	3	100	15.9			PANEL 'LPC'	38
39	-----		25.6		-	-	-	-		16.2		-----	40
41	-----			24.2	-	-	-	-			13.7	-----	42
		34.55	30.03	29.5	SUB-TOTALS				18	24.96	17.76		

CONNECTED LOAD:

A:	52.5 KVA	=	190 A
B:	55.0 KVA	=	199 A
C:	47.3 KVA	=	171 A

Drawing 22. Panel LPA Existing Loads

PANEL LPB **MAIN:** 225A MCB **VOLTAGE:** 480Y/ 277 3 PH 4 W
AIC: 25,000 **MOUNTING:** SURFACE **NOTE:**
LOCATION: ELECTRICAL RM. 010 100% RATED NEUTRAL BUS

CKT	EQUIPMENT SERVED	LOAD (KVA) A	B	C	BREAKER P	AMPS	BREAKER P	AMPS	LOAD (KVA) A	B	C	EQUIPMENT SERVED	CKT
1	L: ARENA COURT	2.7			1	20	1	20	2.4			L: ARENA / THEATER	2
3	L: ARENA COURT		2.7		1	20	1	20		1.2		L: ARENA SEAT	4
5	L: ARENA COURT			2.7	1	20	1	20			1.5	L: ARENA SEAT	6
7	L: ARENA COURT	2.7			1	20	1	20	1			L: ARENA SEAT	8
9	L: ARENA COURT		2.7		1	20	1	20		0.8		L: ARENA SEAT	10
11	L: ARENA COURT			2.7	1	20	1	20			1	L: ARENA SEAT	12
13	L: ARENA COURT	2.7			1	20	1	20	0.8			L: ARENA SEAT	14
15	L: ARENA COURT		2.7		1	20	1	20		1		L: ARENA SEAT	16
17	L: ARENA COURT			2.7	1	20	1	20			0.8	L: ARENA SEAT	18
19	L: ARENA COURT	2.7			1	20	1	20	1			L: ARENA SEAT	20
21	L: ARENA DOWNLIGHT		0.4		1	20	1	20		0.8		L: ARENA SEAT	22
23	L: LOWER ENTRANCES			1.2	1	20	1	20			0.7	L: ARENA SEAT	24
25	L: TOILETS UPPER LEVEL	1.8			1	20	1	20	0.7			L: ARENA SEAT	26
27	L: TOILET LOWER LEVEL		1.8		1	20	1	20		1.7		L: ARENA SEAT	28
29	L: 010 & 011			1.2	1	20	1	20			1.7	L: ARENA SEAT	30
31	L: TOILET LOWER LEVEL	2			1	20	1	20	1.1			L: ARENA SEAT	32
33	L: CORRIDOR 116		2		1	20	1	20		1		L: ARENA SEAT	34
35	SPARE				1	20	1	20			1.3	L: CONCESSION	36
37	SPARE				1	20	1	20	0.6			L: UPPER ENTRANCES	38
39	SPARE				1	20	1	20		2.6		L: WALL LIGHTING	40
41	SPARE				1	20	1	20			0.6	L: STAIRS NW & SW	42
43	SPACE				-	-	-	-				SPACE	44
45	SPACE				-	-	-	-				SPACE	46
47	SPACE				-	-	-	-				SPACE	48
49	SPACE				-	-	-	-				SPACE	50
51	SPACE				-	-	-	-				SPACE	52
53	SPACE				-	-	-	-				SPACE	54
55	PANEL 'RPB' TRANSFORMER	18.4			3	150	-	-				SPACE	56
57	-----		17.3		-	-	-	-				SPACE	58
59	-----			17.1	-	-	-	-				SPACE	60
		33	29.6	27.6	SUB-TOTALS				7.6	9.1	7.6		

CONNECTED LOAD:

A: 40.6 KVA = 147 A
B: 38.7 KVA = 140 A
C: 35.2 KVA = 127 A

Drawing 23. Panel LPB Existing Loads

PANEL SITE — MAIN: 225A MCB — VOLTAGE: 480Y/ 277 3 PH 4 W
AIC: 25,000 — MOUNTING: SURFACE — NOTE:
LOCATION: ROOM 011 — 100% RATED NEUTRAL BUS

CKT	EQUIPMENT SERVED	LOAD (KVA) A	B	C	BREAKER P	AMPS	BREAKER P	AMPS	LOAD (KVA) A	B	C	EQUIPMENT SERVED	CKT
1	TENNIS COURT	1.8			2	20	1	20	1.8			SITE LIGHTING	2
3	-----		1.8		-	-	1	20		1.8		SITE LIGHTING	4
5	TENNIS COURT			1.8	2	20	1	20			1.8	SITE LIGHTING	6
7	-----	1.8			-	-	1	20	2			SITE LIGHTING	8
9	TENNIS COURT		1.8		2	20	1	20		2		SITE LIGHTING	10
11	-----			1.8	-	-	1	20			2.7	SITE LIGHTING	12
13	TENNIS COURT	1.8			2	20	1	20	2.4			SITE LIGHTING	14
15	-----		1.8		-	-	1	20		0.5		SITE LIGHTING	16
17	TENNIS COURT			1.8	2	20	1	20				SPARE	18
19	-----	1.8			-	-	3	20	1.3			DOCK LEVELER	20
21	TENNIS COURT		1.8		2	20	-	-		1.3		-----	22
23	-----			1.8	-	-	-	-			1.3	-----	24
25	TENNIS COURT	1.8			2	20	3	20	1.2			RAIN WATER	26
27	-----		1.8		-	-	-	-		1.2		-----	28
29	TENNIS COURT			1.8	2	20	-	-			1.2	-----	30
31	-----	1.8			-	-	3	25	4.2			PUMP RWHB #1 & 2	32
33	TENNIS COURT		1.8		2	20	-	-		4.2		-----	34
35	-----			1.8	-	-	-	-			4.2	-----	36
37	TENNIS COURT	1.8			2	20	1	20	1.2			"SAIL" LIGHTING	38
39	-----		1.8		-	-	1	20		1.2		"SAIL" LIGHTING	40
41	TENNIS COURT			1.8	2	20	1	20			0.4	CANOPY LIGHTING	42
43	-----	1.8			-	-	1	20	1.8			SOFFIT LIGHTING	44
45	TENNIS COURT		1.8		2	20	1	20		1.5		SOFFIT LIGHTING	46
47	-----			1.8	-	-	1	20			0.4	ENTRANCE (2)	48
49	TENNIS COURT	1.8			2	20	-	-				SPACE	50
51	-----		1.8		-	-	-	-				SPACE	52
53	TENNIS COURT			1.8	2	20	-	-				SPACE	54
55	-----	1.8			-	-	-	-				SPACE	56
57	TENNIS COURT		1.8		2	20	-	-				SPACE	58
59	-----			1.8	-	-	-	-				SPACE	60
61	TENNIS COURT	1.8			2	20	-	-				SPACE	62
63	-----		1.8		-	-	-	-				SPACE	64
65	SPARE				1	20	-	-				SPACE	66
67	SPARE				1	20	-	-				SPACE	68
69	SPACE				-	-	-	-				SPACE	70
71	SPACE				-	-	-	-				SPACE	72
73	SPACE				-	-	-	-				SPACE	74
75	SPACE				-	-	-	-				SPACE	76
77	SPACE				-		-	-				SPACE	78
79	SPACE				-	-	-	-				SPACE	80
81	SPACE				-	-	-	-				SPACE	82
83	SPACE				-	-	-	-				SPACE	84
		19.8	19.8	18	SUB-TOTALS				15.9	13.7	12		

CONNECTED LOAD:

A: 35.7 KVA = 129 A
B: 33.5 KVA = 121 A
C: 30 KVA = 108 A

Drawing 24. Panel Site Existing Loads

Revised Panelboards and Modified Circuits

PANELBOARD SIZING WORKSHEET

Panel Tag---------->				LPA	Panel Location:			Electric Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Toilets	2300	w	0.90	2300	2556	
2	A	Lighting	3	Fitness	1566	w	0.90	1566	1740	
3	B	Lighting	3	Corridor	2100	w	0.90	2100	2333	
4	B	Lighting	3	Fitness	1711	w	0.90	1711	1901	
5	C	Lighting	3	Corridor	1700	w	0.90	1700	1889	
6	C	Lighting	3	Fitness	675	w	0.90	675	750	
7	A	Lighting	3	Corridor	2700	w	0.90	2700	3000	
8	A	Space			0	w		0	0	
9	B	Lighting	3	Dance	1500	w	0.90	1500	1667	
10	B	Lighting	3	Multi	2800	w	0.90	2800	3111	
11	C	Space	3		0	w		0	0	
12	C	Lighting	3	Storage	1800	w	0.90	1800	2000	
13	A	Space	3		0	w		0	0	
14	A	Lighting	3	Sail	400	w	0.90	400	444	
15	B	Lighting	3	Lounge	800	w	0.90	800	889	
16	B	Lighting	3	Offices	3200	w	0.90	3200	3556	
17	C	Spare	9		0	w		0	0	
18	C	Lighting	3	Classroom	2800	w	0.90	2800	3111	
19	A	Spare	9		0	w		0	0	
20	A	Space			0	w		0	0	
21	B	Space			0	w		0	0	
22	B	Space			0	w		0	0	
23	C	Space			0	w		0	0	
24	C	Space			0	w		0	0	
25	A	Space			0	w		0	0	
26	A	Space			0	w		0	0	
27	B	Space			0	w		0	0	
28	B	Space			0	w		0	0	
29	C	Space			0	w		0	0	
30	C	Space			0	w		0	0	
31	A	Space			0	w		0	0	
32	A	Space			0	w		0	0	
33	B	Panel DP	9		1080	w		1080	1350	
34	B	Space			0	w		0	0	
35	C	* * *	9	* * *	1080	w		1080	1350	
36	C	Space			0	w		0	0	
37	A	Transformer RPA	9	Electric	25900	w		25900	32375	
38	A	Panel LPC	9	Electric	15900	w		15900	19875	
39	B	* * *	9	* * *	25600	w		25600	32000	
40	B	* * *	9	* * *	16200	w		16200	20250	
41	C	* * *	9	* * *	24200	w		24200	30250	
42	C	* * *	9	* * *	13700	w		13700	17125	
PANEL TOTAL								149.7	183.5	Amps= 220.8

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					48.8	60.0	34%	216.6
PHASE TOTAL	B					55.0	67.1	39%	242.1
PHASE TOTAL	C					46.0	47.0	27%	169.7

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		26.1	28.9		26.1	28.9	0.90		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		123.7	154.6		123.7	154.6	0.80		
Total Demand Loads						149.7	183.5			
Spare Capacity			20%			29.9	36.7			
Total Design Loads						179.7	220.2	0.82	Amps=	265.0

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 20. Panel LPA New Loads

Panelboard	
Tag	LPA
Voltage System	480Y/ 277V
Calculated Design Load (kW)	180
Calculated Power Factor	0.82
Calculated Design Load (kVA)	220.226
Calculated Design Load (A)	265.0132371
Feeder	
Feeder Protection Size	400
Number of Sets	2
Wire Size	
Phase	2/0
Neutral	2/0
Ground	3
Wire Area (table 5)	
Each Phase	0.2223
Total – All phases	0.6669
Neutral	0.2223
Ground	0.0973
Total – All Wires	0.9865
Minimum Conduit Area (above * 2.5)	2.46625
Conduit Size (Table 4)	2"
Conduit Size (Table C.1)	2-1/2"
Feeder Length	25 ft
Final Voltage Drop (V)	12.3 V
Final Voltage Drop (%)	2.60%
Was feeder re-sized?	NO

Table 21. Panel LPA Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	480Y/277V,3PH,4W	PANEL TAG:	LPA	MIN. C/B AIC:	35k
SIZE/TYPE BUS:	400A	PANEL LOCATION:	Electric Room	OPTIONS:	
SIZE/TYPE MAIN:	400A/3P MCB	PANEL MOUNTING:	SURFACE		

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Toilets	2300	20A/1P	1	*			2	20A/1P	1566	Fitness	Lighting
Lighting	Corridor	2100	20A/1P	3		*		4	20A/1P	1711	Fitness	Lighting
Lighting	Corridor	1700	20A/1P	5			*	6	20A/1P	675	Fitness	Lighting
Lighting	Corridor	2700	20A/1P	7	*			8	20A/1P	0		Space
Lighting	Dance	1500	20A/1P	9		*		10	20A/1P	2800	Multi	Lighting
Space		0	20A/1P	11			*	12	20A/1P	1800	Storage	Lighting
Space		0	20A/1P	13	*			14	20A/1P	400	Sail	Lighting
Lighting	Lounge	800	20A/1P	15		*		16	20A/1P	3200	Offices	Lighting
Spare		0	20A/1P	17			*	18	20A/1P	2800	Classroom	Lighting
Spare		0	20A/1P	19	*			20	20A/1P	0		Space
Space		0	20A/1P	21		*		22	20A/1P	0		Space
Space		0	20A/1P	23			*	24	20A/1P	0		Space
Space		0	20A/1P	25	*			26	20A/1P	0		Space
Space		0	20A/1P	27		*		28	20A/1P	0		Space
Space		0	20A/1P	29			*	30	20A/1P	0		Space
Space		0	20A/1P	31	*			32	20A/1P	0		Space
Panel DP		1080	50A/2P	33		*		34	20A/1P	0		Space
* * *	* * *	1080		35			*	36	20A/1P	0		Space
Transformer RPA	Electric	25900	125A/3P	37	*			38	100A/3P	15900	Electric	Panel LPC
* * *	* * *	25600		39		*		40		16200	* * *	* * *
* * *	* * *	24200		41			*	42		13700	* * *	* * *

CONNECTED LOAD (KW) - A Ph.	48.77	TOTAL DESIGN LOAD (KW)	179.65
CONNECTED LOAD (KW) - B Ph.	54.99	POWER FACTOR	0.82
CONNECTED LOAD (KW) - C Ph.	45.96	TOTAL DESIGN LOAD (AMPS)	265

Table 22. Panel LPA Schedule

PANELBOARD SIZING WORKSHEET

Panel Tag---------->	LPB	Panel Location:	Electric Room
Nominal Phase to Neutral Voltage------->	277	Phase:	3
Nominal Phase to Phase Voltage-------->	480	Wires:	4

Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Arena	2700	w		2700	3375	
2	A	Lighting	3	Arena	2400	w		2400	3000	
3	B	Lighting	3	Arena	2700	w		2700	3375	
4	B	Lighting	3	Arena	1200	w		1200	1500	
5	C	Lighting	3	Arena	2700	w		2700	3375	
6	C	Lighting	3	Arena	1500	w		1500	1875	
7	A	Lighting	3	Arena	2700	w		2700	3375	
8	A	Lighting	3	Arena	1000	w		1000	1250	
9	B	Lighting	3	Arena	2700	w		2700	3375	
10	B	Lighting	3	Arena	800	w		800	1000	
11	C	Lighting	3	Arena	2700	w		2700	3375	
12	C	Lighting	3	Arena	1000	w		1000	1250	
13	A	Lighting	3	Arena	2700	w		2700	3375	
14	A	Lighting	3	Arena	800	w		800	1000	
15	B	Lighting	3	Arena	2700	w		2700	3375	
16	B	Lighting	3	Arena	100	w		100	125	
17	C	Lighting	3	Arena	2700	w		2700	3375	
18	C	Lighting	3	Arena	800	w		800	1000	
19	A	Lighting	3	Arena	2700	w		2700	3375	
20	A	Lighting	3	Arena	1000	w		1000	1250	
21	B	Lighting	3	Arena	400	w		400	500	
22	B	Lighting	3	Arena	800	w		800	1000	
23	C	Lighting	3	Toilets	1200	w		1200	1500	
24	C	Lighting	3	Arena	700	w		700	875	
25	A	Lighting	3	Toilets	1800	w		1800	2250	
26	A	Lighting	3	Arena	700	w		700	875	
27	B	Lighting	3	Toilets	1800	w		1800	2250	
28	B	Lighting	3	Arena	1700	w		1700	2125	
29	C	Lighting	3	Electric	1200	w		1200	1500	
30	C	Lighting	3	Arena	1700	w		1700	2125	
31	A	Lighting	3	Toilets	2000	w		2000	2500	
32	A	Lighting	3	Arena	1100	w		1100	1375	
33	B	Lighting	3	Corridor	2000	w		2000	2500	
34	B	Lighting	3	Arena	1000	w		1000	1250	
35	C	Space	9		0	w		0	0	
36	C	Lighting	3	Lobby	564	w		564	705	
37	A	RPB XMFR	9	Electric	18400	w		18400	23000	
38	A	Space	9		0	w		0	0	
39	B	* * *	9	* * *	17300	w		17300	21625	
40	B	Lighting	3	Wall	2600	w		2600	3250	
41	C	* * *	9	* * *	17100	w		17100	21375	
42	C	Lighting	3	Stairs	600	w		600	750	
PANEL TOTAL								112.3	140.3	Amps= 168.9

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					40.0	50.0	37%	180.5
PHASE TOTAL	B					37.8	47.3	35%	170.6
PHASE TOTAL	C					34.5	38.7	28%	139.5

LOAD CATAGORIES			Connected			Demand				Ver. 104
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		59.5	74.3		59.5	74.3	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		52.8	66.0		52.8	66.0	0.80		
Total Demand Loads						112.3	140.3			
Spare Capacity			20%			22.5	28.1			
Total Design Loads						134.7	168.4	0.80	Amps=	202.6

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 23. Panel LPB New Loads

Panelboard	
Tag	LPB
Voltage System	480Y/ 277V
Calculated Design Load (kW)	134.7
Calculated Power Factor	0.8
Calculated Design Load (kVA)	168.4
Calculated Design Load (A)	202.6
Feeder	
Feeder Protection Size	225
Number of Sets	1
Wire Size	
Phase	4/0
Neutral	4/0
Ground	4
Wire Area (table 5)	
Each Phase	0.3237
Total – All phases	0.9711
Neutral	0.3237
Ground	0.0824
Total – All Wires	1.3772
Minimum Conduit Area (above * 2.5)	3.443
Conduit Size (Table 4)	2- 1/2"
Conduit Size (Table C.1)	2-1/2"
Feeder Length	100ft
Final Voltage Drop (V)	10.5 V
Final Voltage Drop (%)	2.20%
Was feeder re-sized?	NO

Table 24. Panel LPB Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	LPB	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Arena	2700	20A/1P	1	*			2	20A/1P	2400	Arena	Lighting
Lighting	Arena	2700	20A/1P	3		*		4	20A/1P	1200	Arena	Lighting
Lighting	Arena	2700	20A/1P	5			*	6	20A/1P	1500	Arena	Lighting
Lighting	Arena	2700	20A/1P	7	*			8	20A/1P	1000	Arena	Lighting
Lighting	Arena	2700	20A/1P	9		*		10	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	11			*	12	20A/1P	1000	Arena	Lighting
Lighting	Arena	2700	20A/1P	13	*			14	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	15		*		16	20A/1P	100	Arena	Lighting
Lighting	Arena	2700	20A/1P	17			*	18	20A/1P	800	Arena	Lighting
Lighting	Arena	2700	20A/1P	19	*			20	20A/1P	1000	Arena	Lighting
Lighting	Arena	400	20A/1P	21		*		22	20A/1P	800	Arena	Lighting
Lighting	Toilets	1200	20A/1P	23			*	24	20A/1P	700	Arena	Lighting
Lighting	Toilets	1800	20A/1P	25	*			26	20A/1P	700	Arena	Lighting
Lighting	Toilets	1800	20A/1P	27		*		28	20A/1P	1700	Arena	Lighting
Lighting	Electric	1200	20A/1P	29			*	30	20A/1P	1700	Arena	Lighting
Lighting	Toilets	2000	20A/1P	31	*			32	20A/1P	1100	Arena	Lighting
Lighting	Corridor	2000	20A/1P	33		*		34	20A/1P	1000	Arena	Lighting
Space	0	0	20A/1P	35			*	36	20A/1P	564	Lobby	Lighting
RPB XMFR	Electric	18400	150A/3P	37	*			38	20A/1P	0		Space
* * *	* * *	17300		39		*		40	20A/1P	2600	Wall	Lighting
* * *	* * *	17100		41			*	42	20A/1P	600	Stairs	Lighting

CONNECTED LOAD (KW) - A Ph.	40.00	TOTAL DESIGN LOAD (KW)	134.72
CONNECTED LOAD (KW) - B Ph.	37.80	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	34.46	TOTAL DESIGN LOAD (AMPS)	203

Table 25. Panel LPB Schedule

PANELBOARD SIZING WORKSHEET

Panel Tag---------->				Site	Panel Location:			Electric Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
1	A	Lighting	3	Tennis	1800	w		1800	2250	
2	A	Lighting	3	Site	1800	w		1800	2250	
3	B	* * *	3	* * *	1800	w		1800	2250	
4	B	Lighting	3	Site	1800	w		1800	2250	
5	C	Lighting	3	Tennis	1800	w		1800	2250	
6	C	Lighting	3	Site	1800	w		1800	2250	
7	A	* * *	3	* * *	1800	w		1800	2250	
8	A	Lighting	3	Site	2000	w		2000	2500	
9	B	Lighting	3	Tennis	1800	w		1800	2250	
10	B	Lighting	3	Site	200	w		200	250	
11	C	* * *	3	* * *	1800	w		1800	2250	
12	C	Lighting	3	Site	2700	w		2700	3375	
13	A	Lighting	3	Tennis	1800	w		1800	2250	
14	A	Lighting	3	Site	2400	w		2400	3000	
15	B	* * *	3	* * *	1800	w		1800	2250	
16	B	Lighting	3	Site	500	w		500	625	
17	C	Lighting	3	Tennis	1800	w		1800	2250	
18	C	Spare	9			w		0	0	
19	A	* * *	3	* * *	1800	w		1800	2250	
20	A	Dock Leveler	9	Site	1300	w		1300	1625	
21	B	Lighting	3	Tennis	1800	w		1800	2250	
22	B	* * *	9	* * *	1300	w		1300	1625	
23	C	* * *	3	* * *	1800	w		1800	2250	
24	C	* * *	9	* * *	1300	w		1300	1625	
25	A	Lighting	3	Tennis	1800	w		1800	2250	
26	A	Rain Water	9	Site	1200	w		1200	1500	
27	B	* * *	3	* * *	1800	w		1800	2250	
28	B	* * *	9	* * *	1200	w		1200	1500	
29	C	Lighting	3	Tennis	1800	w		1800	2250	
30	C	* * *	9	* * *	1200	w		1200	1500	
31	A	* * *	3	* * *	1800	w		1800	2250	
32	A	Pumps	9	Site	4200	w		4200	5250	
33	B	Lighting	3	Tennis	1800	w		1800	2250	
34	B	* * *	9	* * *	4200	w		4200	5250	
35	C	* * *	9	* * *	1800	w		1800	2250	
36	C	* * *	9	* * *	4200	w		4200	5250	
37	A	Lighting	3	Tennis	1800	w		1800	2250	
38	A	Lighting	3	Site	1200	w		1200	1500	
39	B	* * *	3	* * *	1800	w		1800	2250	
40	B	Lighting	3	Site	1375	w		1375	1719	
41	C	Lighting	3	Tennis	1800	w		1800	2250	
42	C	Lighting	3	Site	1638	w		1638	2048	
PANEL TOTAL								75.3	94.1	Amps= 113.3

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					26.7	33.4	36%	120.5
PHASE TOTAL	B					23.2	29.0	31%	104.6
PHASE TOTAL	C					25.4	30.9	33%	111.7

LOAD CATAGORIES			Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		53.4	66.8		53.4	66.8	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		21.9	27.4		21.9	27.4	0.80		
Total Demand Loads						75.3	94.1			
Spare Capacity			20%			15.1	18.8			
Total Design Loads						90.4	113.0	0.80	Amps=	135.9

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 26. Panel Site New Loads on first 42 Circuits

PANELBOARD SIZING WORKSHEET

Panel Tag---------->				Site	Panel Location:			Electric Room		
Nominal Phase to Neutral Voltage------->				277	Phase:			3		
Nominal Phase to Phase Voltage-------->				480	Wires:			4		
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks
43	A	* * *	3	* * *	1800	w		1800	2250	
44	A	Lighting	3	Site	1800	w		1800	2250	
45	B	Lighting	3	Tennis	1800	w		1800	2250	
46	B	Lighting	3	Site	1500	w		1500	1875	
47	C	* * *	3	* * *	1800	w		1800	2250	
48	C	Spare	9			w		0	0	
49	A	Lighting	3	Tennis	1800	w		1800	2250	
50	A	Space				w		0	0	
51	B	* * *	3	* * *	1800	w		1800	2250	
52	B	Space				w		0	0	
53	C	Lighting	3	Tennis	1800	w		1800	2250	
54	C	Space				w		0	0	
55	A	* * *	3	* * *	1800	w		1800	2250	
56	A	Space				w		0	0	
57	B	* * *	3	* * *	1800	w		1800	2250	
58	B	Space				w		0	0	
59	C	* * *	3	* * *	1800	w		1800	2250	
60	C	Space				w		0	0	
61	A	Lighting	3	Tennis	1800	w		1800	2250	
62	A	Space				w		0	0	
63	B	* * *	3	* * *	1800	w		1800	2250	
64	B	Space				w		0	0	
65	C	Spare	9			w		0	0	
66	C	Space				w		0	0	
67	A	Spare	9			w		0	0	
68	A	Space				w		0	0	
69	B	Space				w		0	0	
70	B	Space				w		0	0	
71	C	Space				w		0	0	
72	C	Space				w		0	0	
73	A	Space				w		0	0	
74	A	Space				w		0	0	
75	B	Space				w		0	0	
76	B	Space				w		0	0	
77	C	Space				w		0	0	
78	C	Space				w		0	0	
79	A	Space				w		0	0	
80	A	Space				w		0	0	
81	B	Space				w		0	0	
82	B	Space				w		0	0	
83	C	Space				w		0	0	
84	C	Space				w		0	0	
PANEL TOTAL								23.1	28.9	Amps= 34.7

PHASE LOADING						kW	kVA	%	Amps
PHASE TOTAL	A					9.0	11.3	39%	40.6
PHASE TOTAL	B					8.7	10.9	38%	39.3
PHASE TOTAL	C					5.4	6.8	23%	24.4

	LOAD CATAGORIES		Connected			Demand				Ver. 1.04
			kW	kVA	DF	kW	kVA	PF		
1	receptacles		0.0	0.0		0.0	0.0			
2	computers		0.0	0.0		0.0	0.0			
3	fluorescent lighting		23.1	28.9		23.1	28.9	0.80		
4	HID lighting		0.0	0.0		0.0	0.0			
5	incandescent lighting		0.0	0.0		0.0	0.0			
6	HVAC fans		0.0	0.0		0.0	0.0			
7	heating		0.0	0.0		0.0	0.0			
8	kitchen equipment		0.0	0.0		0.0	0.0			
9	unassigned		0.0	0.0		0.0	0.0			
Total Demand Loads						23.1	28.9			
Spare Capacity			20%			4.6	5.8			
Total Design Loads						27.7	34.7	0.80	Amps=	41.7

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 27. Panel Site New Loads on second 42 Circuits

Panelboard		
Tag		Site
Voltage System		480Y/ 277V
Calculated Design Load (kW)		118.1
Calculated Power Factor		0.8
Calculated Design Load (kVA)		147.7
Calculated Design Load (A)		177.7
Feeder		
Feeder Protection Size		225
Number of Sets		1
Wire Size		
	Phase	4/0
	Neutral	4/0
	Ground	4
Wire Area (table 5)		
	Each Phase	0.3237
	Total – All phases	0.9711
	Neutral	0.3237
	Ground	0.0824
	Total – All Wires	1.3772
Minimum Conduit Area (above * 2.5)		3.443
Conduit Size (Table 4)		2- 1/2"
Conduit Size (Table C.1)		2-1/2"
Feeder Length		100ft
Final Voltage Drop (V)		10.5V
Final Voltage Drop (%)		2.20%
Was feeder re-sized?		NO

Table 28. Panel Site Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	Site	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Tennis	1800	20A/2P	1	*			2	20A/1P	1800	Site	Lighting
* * *	* * *	1800		3		*		4	20A/1P	1800	Site	Lighting
Lighting	Tennis	1800	20A/2P	5			*	6	20A/1P	1800	Site	Lighting
* * *	* * *	1800		7	*			8	20A/1P	2000	Site	Lighting
Lighting	Tennis	1800	20A/2P	9		*		10	20A/1P	200	Site	Lighting
* * *	* * *	1800		11			*	12	20A/1P	2700	Site	Lighting
Lighting	Tennis	1800	20A/2P	13	*			14	20A/1P	2400	Site	Lighting
* * *	* * *	1800		15		*		16	20A/1P	500	Site	Lighting
Lighting	Tennis	1800	20A/2P	17			*	18	20A/1P	0	0	Spare
* * *	* * *	1800		19	*			20	20A/3P	1300	Site	Dock Leveler
Lighting	Tennis	1800	20A/2P	21		*		22		1300	* * *	* * *
* * *	* * *	1800		23			*	24		1300	* * *	* * *
Lighting	Tennis	1800	20A/2P	25	*			26	20A/3P	1200	Site	Rain Water
* * *	* * *	1800		27		*		28		1200	* * *	* * *
Lighting	Tennis	1800	20A/2P	29			*	30		1200	* * *	* * *
* * *	* * *	1800		31	*			32	20A/3P	4200	Site	Pumps
Lighting	Tennis	1800	20A/2P	33		*		34		4200	* * *	* * *
* * *	* * *	1800		35			*	36		4200	* * *	* * *
Lighting	Tennis	1800	20A/2P	37	*			38	20A/1P	1200	Site	Lighting
* * *	* * *	1800		39		*		40	20A/1P	1375	Site	Lighting
Lighting	Tennis	1800	20A/2P	41			*	42	20A/1P	1638	Site	Lighting

CONNECTED LOAD (KW) - A Ph.	26.70	TOTAL DESIGN LOAD (KW)	90.38
CONNECTED LOAD (KW) - B Ph.	23.18	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	25.44	TOTAL DESIGN LOAD (AMPS)	136

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W	PANEL TAG:	Site	MIN. C/B AIC:	10K
SIZE/TYPE BUS:	225A	PANEL LOCATION:	Electric Room	OPTIONS:	PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN:	225A/3P C/B	PANEL MOUNTING:	SURFACE		FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
* * *	* * *	1800		43	*			44	20A/1P	1800	Site	Lighting
Lighting	Tennis	1800	20A/2P	45		*		46	20A/1P	1500	Site	Lighting
* * *	* * *	1800		47			*	48		0	0	Spare
Lighting	Tennis	1800	20A/2P	49	*			50		0	0	Space
* * *	* * *	1800		51		*		52		0	0	Space
Lighting	Tennis	1800	20A/2P	53			*	54		0	0	Space
* * *	* * *	1800		55	*			56		0	0	Space
* * *	* * *	1800	20A/2P	57		*		58		0	0	Space
* * *	* * *	1800		59			*	60		0	0	Space
Lighting	Tennis	1800	20A/2P	61	*			62		0	0	Space
* * *	* * *	1800		63		*		64		0	0	Space
Spare	0	0		65			*	66		0	0	Space
Spare	0	0		67	*			68		0	0	Space
Space	0	0		69		*		70		0	0	Space
Space	0	0		71			*	72		0	0	Space
Space	0	0		73	*			74		0	0	Space
Space	0	0		75		*		76		0	0	Space
Space	0	0		77			*	78		0	0	Space
Space	0	0		79	*			80		0	0	Space
Space	0	0		81		*		82		0	0	Space
Space	0	0		83			*	84		0	0	Space

CONNECTED LOAD (KW) - A Ph.	9.00	TOTAL DESIGN LOAD (KW)	27.72
CONNECTED LOAD (KW) - B Ph.	8.70	POWER FACTOR	0.80
CONNECTED LOAD (KW) - C Ph.	5.40	TOTAL DESIGN LOAD (AMPS)	42

Table 29. Panel Site Schedule

PANELBOARD SIZING WORKSHEET

Panel Tag---------->				DP	Panel Location:			Electric			
Nominal Phase to Neutral Voltage------->				277	Phase:			1			
Nominal Phase to Phase Voltage-------->				554	Wires:			3			
Pos	Ph.	Load Type	Cat.	Location	Load	Units	I. PF	Watts	VA	Remarks	
1	L1	Lighting	3	Gym	1080	w		1080	1350		
2	L1	Lighting	3	Gym	1080	w		1080	1350		
3	L2	Space			0	w		0	0		
4	L2	Space			0	w		0	0		
5	L1	Space			0	w		0	0		
6	L1	Space			0	w		0	0		
7	L2	Space			0	w		0	0		
8	L2	Space			0	w		0	0		
PANEL TOTAL								2.2	2.7	Amps=	4.9
PHASE LOADING								kW	kVA	%	Amps
LEG TOTAL			L1					2.2	2.7	100%	9.7
LEG TOTAL			L2					0.0	0.0		0.0
LOAD CATAGORIES				Connected			Demand				Ver. 1.04
				kW	kVA	DF	kW	kVA	PF		
1	receptacles			0.0	0.0		0.0	0.0			
2	computers			0.0	0.0		0.0	0.0			
3	fluorescent lighting			2.2	2.7		2.2	2.7	0.80		
4	HID lighting			0.0	0.0		0.0	0.0			
5	incandescent lighting			0.0	0.0		0.0	0.0			
6	HVAC fans			0.0	0.0		0.0	0.0			
7	heating			0.0	0.0		0.0	0.0			
8	kitchen equipment			0.0	0.0		0.0	0.0			
9	unassigned			0.0	0.0		0.0	0.0			
Total Demand Loads							2.2	2.7			
Spare Capacity				20%			0.4	0.5			
Total Design Loads							2.6	3.2	0.80	Amps=	5.8

Default Power Factor =	0.80	
Default Demand Factor =	100	%

Table 30. Panel DP New Loads

Panelboard	
Tag	DP
Voltage System	277V
Calculated Design Load (kW)	2.6kW
Calculated Power Factor	0.8
Calculated Design Load (kVA)	3.2kVA
Calculated Design Load (A)	6A
Feeder	
Feeder Protection Size	50
Number of Sets	1
Wire Size	
Phase	6
Neutral	6
Ground	10
Wire Area (table 5)	
Each Phase	0.0507
Total – All phases	0.1521
Neutral	0.0507
Ground	0.0211
Total – All Wires	0.1732
Minimum Conduit Area (above * 2.5)	0.433
Conduit Size (Table 4)	3/4"
Conduit Size (Table C.1)	1"
Feeder Length	100ft
Final Voltage Drop (V)	3.2V
Final Voltage Drop (%)	1.10%
Was feeder re-sized?	NO

Table 31. Panel DP Feeder Sizing

PANELBOARD SCHEDULE

VOLTAGE:	208Y/120V,3PH,4W		PANEL TAG:	DP					MIN. C/B AIC:	10K		
SIZE/TYPE BUS:	225A		PANEL LOCATION:	Electric					OPTIONS:	PROVIDE FEED THROUGH LUGS		
SIZE/TYPE MAIN:	225A/3P C/B		PANEL MOUNTING:	SURFACE						FOR PANELBOARD 1L1B		
DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	L1		L2	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Gym	1080	20A/1P	1	*			2	20A/1P	1080	Gym	Lighting
Space		0	20A/1P	3			*	4	20A/1P	0		Space
Space		0	20A/1P	5	*			6	20A/1P	0		Space
Space		0	20A/1P	7			*	8	20A/1P	0		Space
CONNECTED LOAD (KW) - A Ph.		2.16								TOTAL DESIGN LOAD (KW)		2.59
CONNECTED LOAD (KW) - B Ph.										POWER FACTOR		0.80
CONNECTED LOAD (KW) - C Ph.		0.00								TOTAL DESIGN LOAD (AMPS)		6

Table 32. Panel DP Schedule

Short Circuit and Protective Device Study

Description

A short circuit and protective device study were conducted in order to determine the electrical systems reliability to protect itself from faulty wiring, over-current circumstances, and any other problems that could occur. The short circuit study looked into three components of the electrical system. Those components are the service entrance, the next downstream Panel, and a circuit within that Panel. The protective device study will break down the characteristics of the protection that each of these components have. This report assumes all equipment is to be EATON Corporation and Cutler-Hammer products because the project has not been built or bided.

Short Circuit Calculations

Below are charts that break down the three components from the main switch board 'MDS' to the branch Panel 'MLP' and the circuit for roof top unit 4. The main switch board is 480Y/277V, 3PH. 4W, with a 3200 amp frame, the branch Panel 'MLP' is 480Y/277V, 3PH., 4W with a 600 amp frame, and the roof top unit 4 circuit is a 3P 70A breaker.

Available Fault Current Calculation

by John Sokolik Ver. 6.3
jmp1jds@earthlink.net

Utility Fault Current	0 amperes	kVA =	2000		
		E =	480		
I = kVA x 1000 = trans. FLA / E x 1.732		trans. FLA =	2406		
Isca = trans. FLA x 100 / transformer Z =			2406		
			5.75 %		
Isca = ampere short-circuit current RMS symmetrical.		Isca =	41,838 amperes		
Point to Point Method				Three Phase 480/277	
	Length (distance) FEET	L =	25	Aluminum in Nonmetallic Raceway	
'f ' factor = 1.732 x L x I / N x C x E L-N	(ASC)	Isca =	41,838		
	# conductors per phase	N =	6		
	Phase conductor constant	C =	23,492	Phase Conductor	750 kcmil
	Volt Line to Line	E L-L =	480 Volt		
		f =	0.027		
	Neutral conductor constant	C =	23,492	Neutral Conductor	750 kcmil
Multiplier	Volt Line to Neutral	E L-N =	277 Volt		
		f =	0.046		
M = 1 / 1 + f	Line to Line	M =	0.974		
	Line to Neutral	M =	0.956		

Fault Current at Service Equipment

Isca x M = fault current at terminals of main disconnect L- L =	⟶	40,747 amperes
Isca x M = fault current at terminals of main disconnect L- N =	⟶	39,983 amperes

Table 33. Short Circuit Calculation Switchboard MDS

Fault Current from	Switchboard To Panel MLP				Copper in Metal Raceway		
					Three Phase		
Three Phase Feeder		Length (distance)	L	=	45		
'f ' factor =	1.732 x L x I / N x C x E L-N	(ASC)	Isca	=	40,747	Phase	39,983 Neutral
		# conductors per phase	N	=	2		
		Phase conductor constant	C	=	19,704	Phase Conductor	350 kcmil
		Volt Line to Line	E L-L	=	480	Volt	
			f	=	0.168		
		Neutral conductor constant	C	=	19,704	Neutral Conductor	350 kcmil
		Volt Line to Neutral	E L-N	=	277	Volt	
Multiplier			f	=	0.285		
M = 1 / 1 + f		Line to Line	M	=	0.856		
		Line to Neutral	M	=	0.778		

Isca x M = fault current at terminal of the panel L- L = **34,889** amperes
Isca x M = fault current at terminal of the panel L- N = **31,103** amperes

Calculation does not include motor contribution

Table 34. Short Circuit Calculations Panel MLP

Branch Circuit Fault from	Panel MLP To RTU-4 Branch Circuit				Copper in Metal Raceway		
					Three Phase		
Three Phase Branch		Length (distance)	L	=	300		
'f ' factor =	1.732 x L x I / N x C x E L-N	(ASC)	Isca	=	34,889	Phase	31,103 Neutral
		# conductors per phase	N	=	1		
		Phase conductor constant	C	=	3,806	Phase Conductor	4
		Volt Line to Line	E L-L	=	480	Volt	
			f	=	9.923		
		Neutral conductor constant	C	=	3,806	Neutral Conductor	4
		Volt Line to Neutral	E L-N	=	277	Volt	
Multiplier			f	=	15.329		
M = 1 / 1 + f		Line to Line	M	=	0.092		
		Line to Neutral	M	=	0.061		

Isca x M = fault current at terminal of the panel L- L = **3,194** amperes
Isca x M = fault current at terminal of the panel L- N = **1,905** amperes

Calculation does not include motor contribution

Table 35. Short Circuit Calculation RTU-4

Protective Devices

This portion of the report analyzes the coordination between protective devices used in the short circuit calculation by hand above. The devices that will be analyzed are the main circuit breaker for Switchboard MDS, Distribution Panel MLP, branch circuit RTU-4, and the motor for RTU-4. For proper coordination of protective devices the trip curve should ascend in an upstream fashion for the current rating. Thus, meaning the breaker for the RTU-4 should trip first, then the breaker for Panel MLP, and lastly the breaker for Switchboard MDS. The Time Current Curve (TCC) shown will indicate that indeed the breakers will trip in this fashion, with one altercation. As seen on the curve, if a spike of 3000A were to enter the system from one second or longer there is no differentiation between the MDS breaker and MLP breaker. This may cause little problems in the coordination process between breakers. The breaker type and color is specified for synchronization of TCC.

Switch Board 'MDS' – Magnum DS, RMS MDS-632 3200A 65kAIC

Panel 'MLP' – Thermal Magnetic M-Frame Circuit Breaker Type HLD, 600V, 3P600A, 65kAIC

Circuit 'RTU-4' –Thermal Magnetic F-Frame Circuit Breaker Type FDC, 480V, 3P70A, 35kAIC

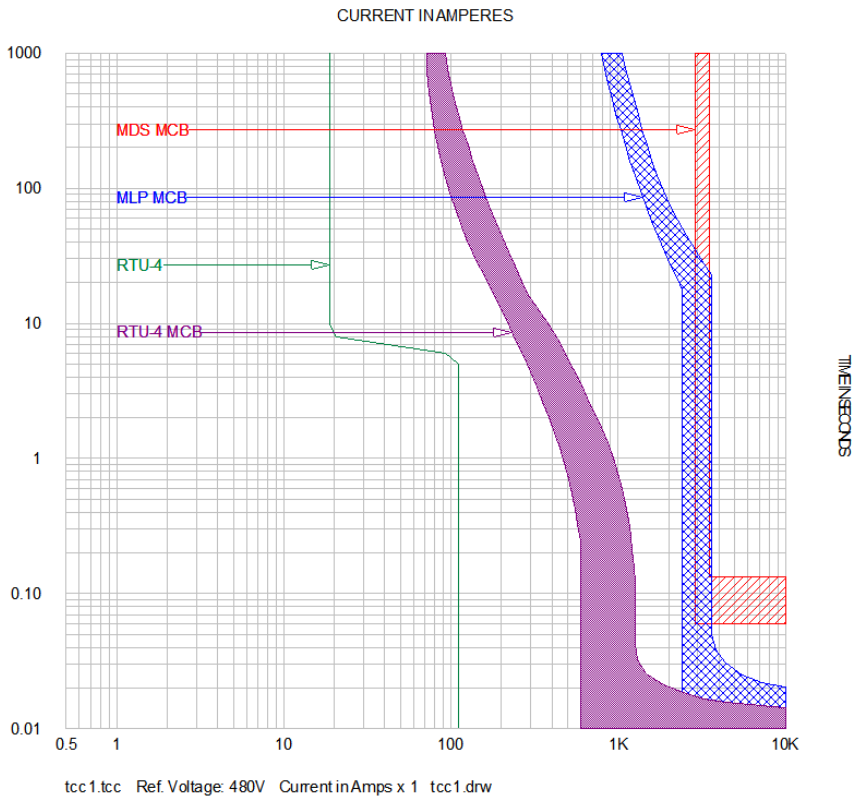


Image 24. TCC Curve for MDS, MLP, RTU-4 Coordination

Electrical Depth 1 – Motor Control Center

Description

This depth looked in to localizing a Motor Control Center within the main mechanical room. The Panel MLP was the primary load center for the space with disconnects located at individual pieces of HVAC equipment. The Motor Control Center took motors with the highest horsepower rating in the 480V Panel MLP and re-localized them with their motor starters and disconnects in the Motor Control Center. The Eaton 2006 Consulting Application Guide for Cutler-Hammer products was used in order to size to produce the layout of the Motor Control Center. Within the calculation the tables used within the guide are specified. See the following charts and drawings to see details of Motor Control Center and Appendix C for specification sheets.

							Table: 430.250 NEC			Table 30.1-88 Eaton			Table 30.1-27 & 30.1-2 Eaton	Table 30.1-27 & 30.1-2 Eaton
Tag	**Equipment**	**HP**	**Volt**	**Phase**	**PF**	**kVA**	**NEC**	**MCA**	**FLA**	**Overcurrent Protection (MCCB)**	**HVAC Controller**	**Starter Type**	**Starter (NEMA Type)**	**# Spaces**
CWP-1	CHD WTR PUMP #1 - CHESA	40	480	3	0.95	32.84	52	54.74	68.42	100	ATC	FVR	3	4
CWP-2	CHD WTR PUMP #2 - CHESA	40	480	3	0.95	32.84	52	54.74	68.42	100	ATC	FVR	3	4
HWP-3	HEATING PUMP - SUSQ	30	480	3	0.95	25.26	40	42.11	52.63	70	ATC	FVR	3	4
HWP-4	HEATING PUMP - SUSQ	30	480	3	0.95	25.26	40	42.11	52.63	70	ATC	FVR	3	4
RTU-3	RTU #3 SUPPLY	25	480	3	0.95	21.47	34	35.79	44.74	70	VFD	AFD	2	6
RTU-2	RTU #2 SUPPLY	20	480	3	0.95	17.05	27	28.42	35.53	50	VFD	AFD	2	6
RTU-1	RTU #1 SUPPLY	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
RTU-3	RTU #3 RETURN	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
RTU-2	RTU #2 RETURN	15	480	3	0.95	13.26	21	22.11	27.63	45	VFD	AFD	2	4
HWP-1	HEATING PUMP #1 - CHESA	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
HWP-2	HEATING PUMP #2 - CHESA	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
PWP	POOL PUMP	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
DWP-1	PUMP DWP #1	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
DWP-2	PUMP DWP #2	7.5	480	3	0.95	6.95	11	11.58	14.47	25	ATC	FVR	1	3
RTU-1	RTU #1 RETURN	5	480	3	0.95	4.80	7.6	8.00	10.00	15	VFD	AFD	0	4
BP-1	BOILER #1	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
BP-2	BOILER #2	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
BP-3	BOILER #3	3	480	3	0.85	3.39	4.8	5.65	7.06	15	ATC	FVR	0	3
Totals						244.23		294	367					68
													Sections:	6

Notes:
1) Manufacturer : Eaton Freedom 2100 Series, bucket size = 6"
2) MCC will be feed from the Main Switchboard (MDS)
3) The MDS will contain a 400A drawout type circuit breaker
4) The feed to the MCC will be 2 sets of 4#3/0 + 1#6GRD. in 3" C.

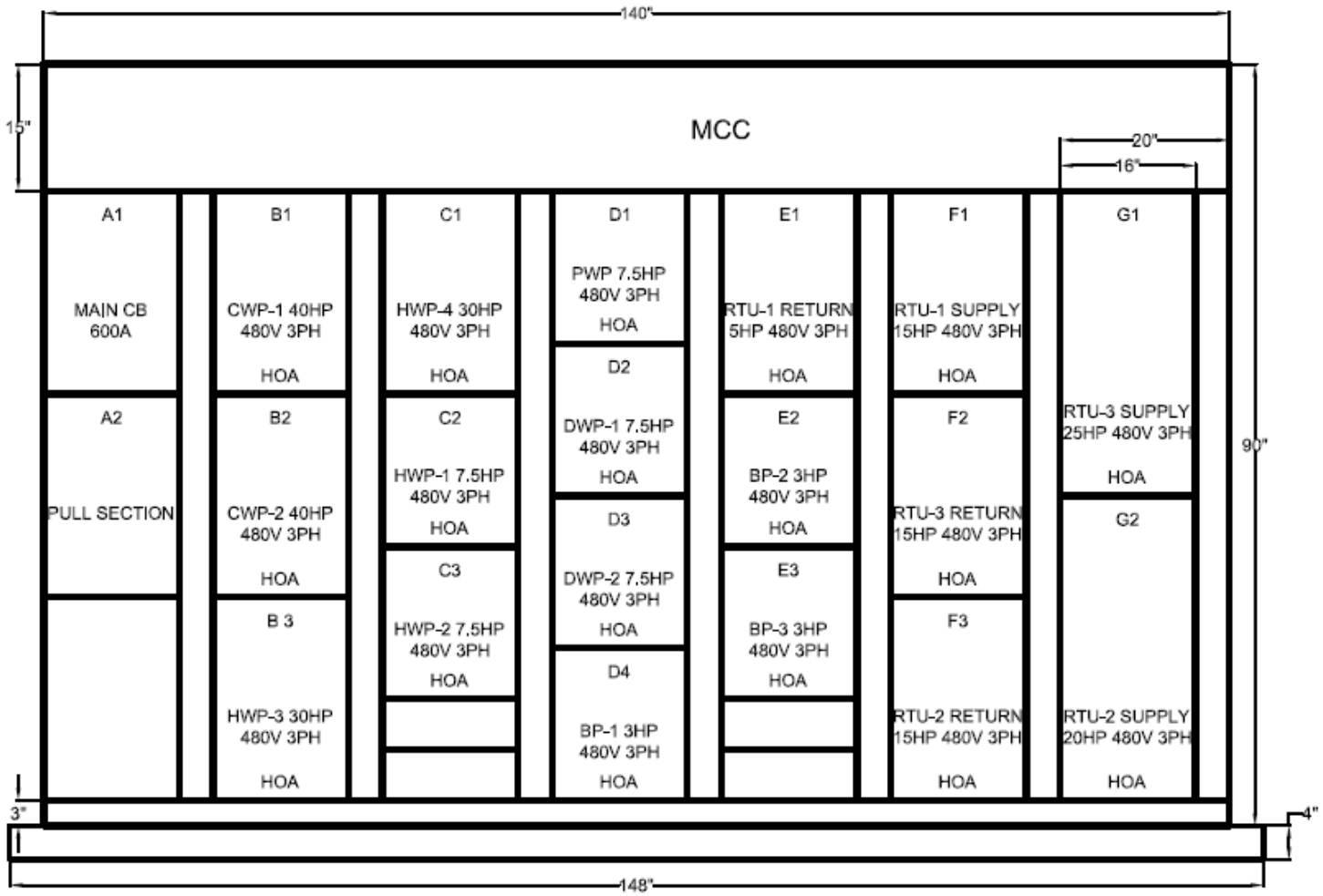
Table 36. MCC Calculations

MOTOR CONTROL CENTER: MCC LOCATION: MECHANICAL ROOM 137

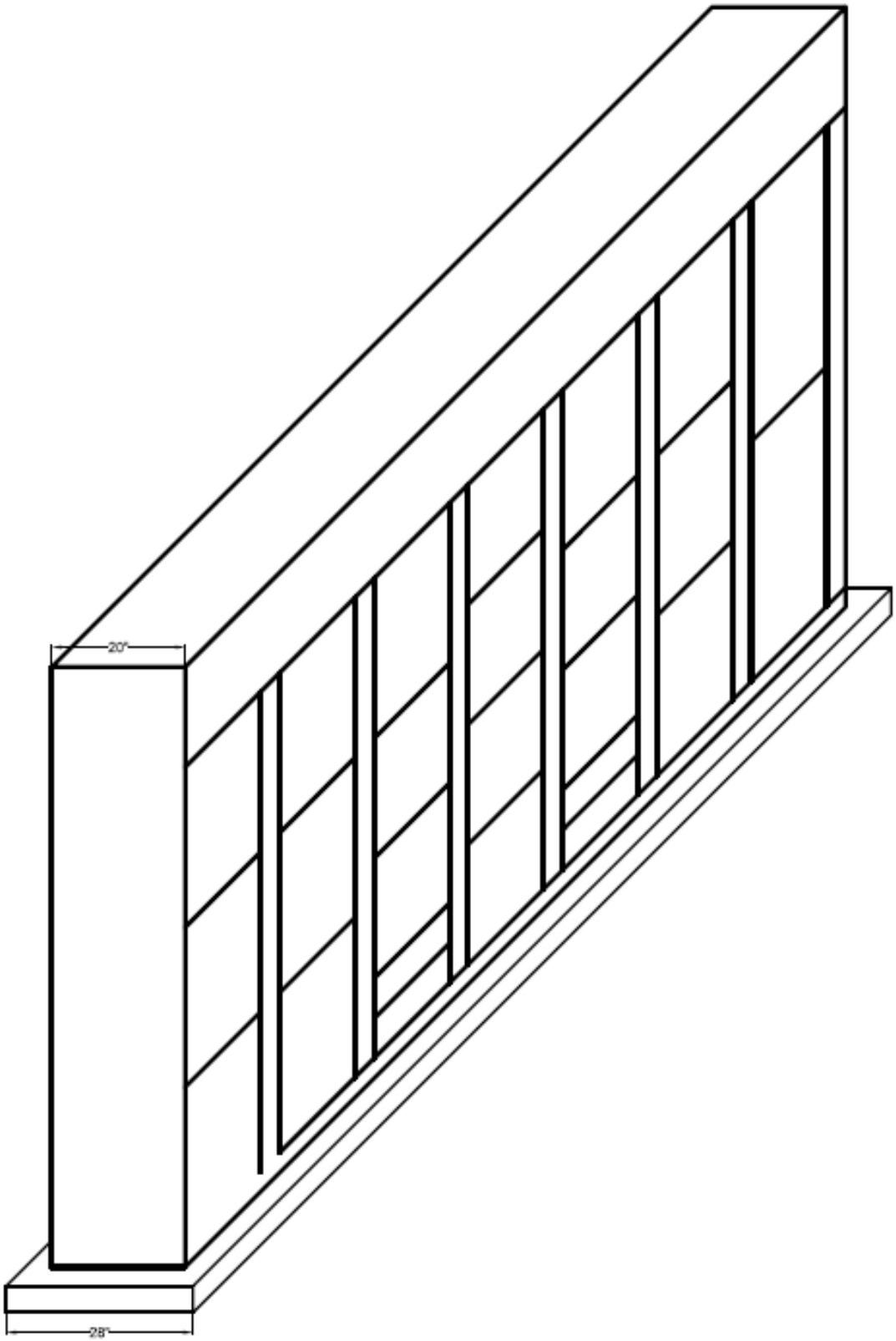
AMPS: 600 VOLTS: 480/277V 3 PH, 4 W, 60 Hz, NEMA: 2 AIC: 65,000

UNIT NO.	CIRCUIT	HP/KVA	FLA	STARTER		CIRCUIT PROTECTION		FEEDER	NOTES
				TYPE	SIZE	TYPE	TRIP		
A1	MAIN CB	–	–	-	–	-	–	(2)3#350MCM+1#6GRDIN3–1/2"C	-
A2	PULL SECTION	–	–	-	–	-	–	–	-
A3	SPARE	–	–	-	–	-	–	–	-
B1	CWP-1	40 HP	68	FVR	3	MCCB	100	3#3 + 1#8GRD. IN 1–1/4" C.	-
B2	CWP-2	40 HP	68	FVR	3	MCCB	100	3#3 + 1#8GRD. IN 1–1/4" C.	-
B3	HWP-3	30 HP	52	FVR	3	MCCB	70	3#4 + 1#8GRD. IN 1–1/4" C.	-
C1	HWP-4	30 HP	52	FVR	3	MCCB	70	3#4 + 1#8GRD. IN 1–1/4" C.	-
C2	HWP-1	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
C3	HWP-2	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D1	PWP	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D2	DWP-1	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D3	DWP-2	7.5 HP	15	FVR	1	MCCB	25	3#12 + 1#12GRD. IN 3/4" C.	-
D4	BP-1	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E1	RTU-1 RETURN	3 HP	7	AFD	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E2	BP-2	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
E3	BP-3	3 HP	7	FVR	0	MCCB	15	3#12 + 1#12GRD. IN 3/4" C.	-
F1	RTU-1 SUPPLY	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
F2	RTU-3 RETURN	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
F3	RTU-2 RETURN	15 HP	28	AFD	2	MCCB	45	3#8 + 1#10GRD. IN 3/4" C.	-
G1	RTU-3 SUPPLY	25 HP	45	AFD	2	MCCB	70	3#6 + 1#8GRD. IN 1" C.	-
G2	RUT-2 SUPPLY	20 HP	36	AFD	2	MCCB	70	3#8 + 1#10GRD. IN 3/4" C.	-

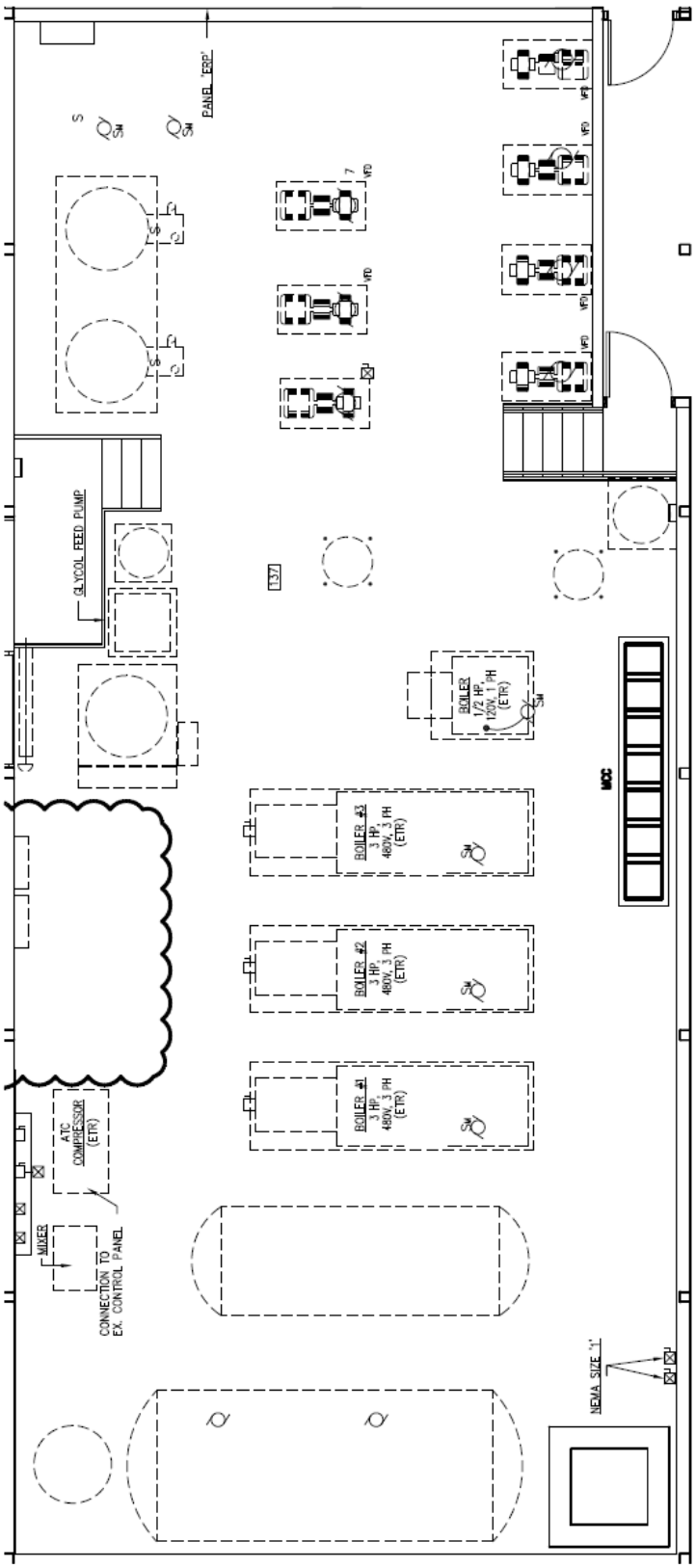
Table 37. MCC Schedule



Drawing 14. MCC Elevation



Drawing 15. MCC Isometric Veiw



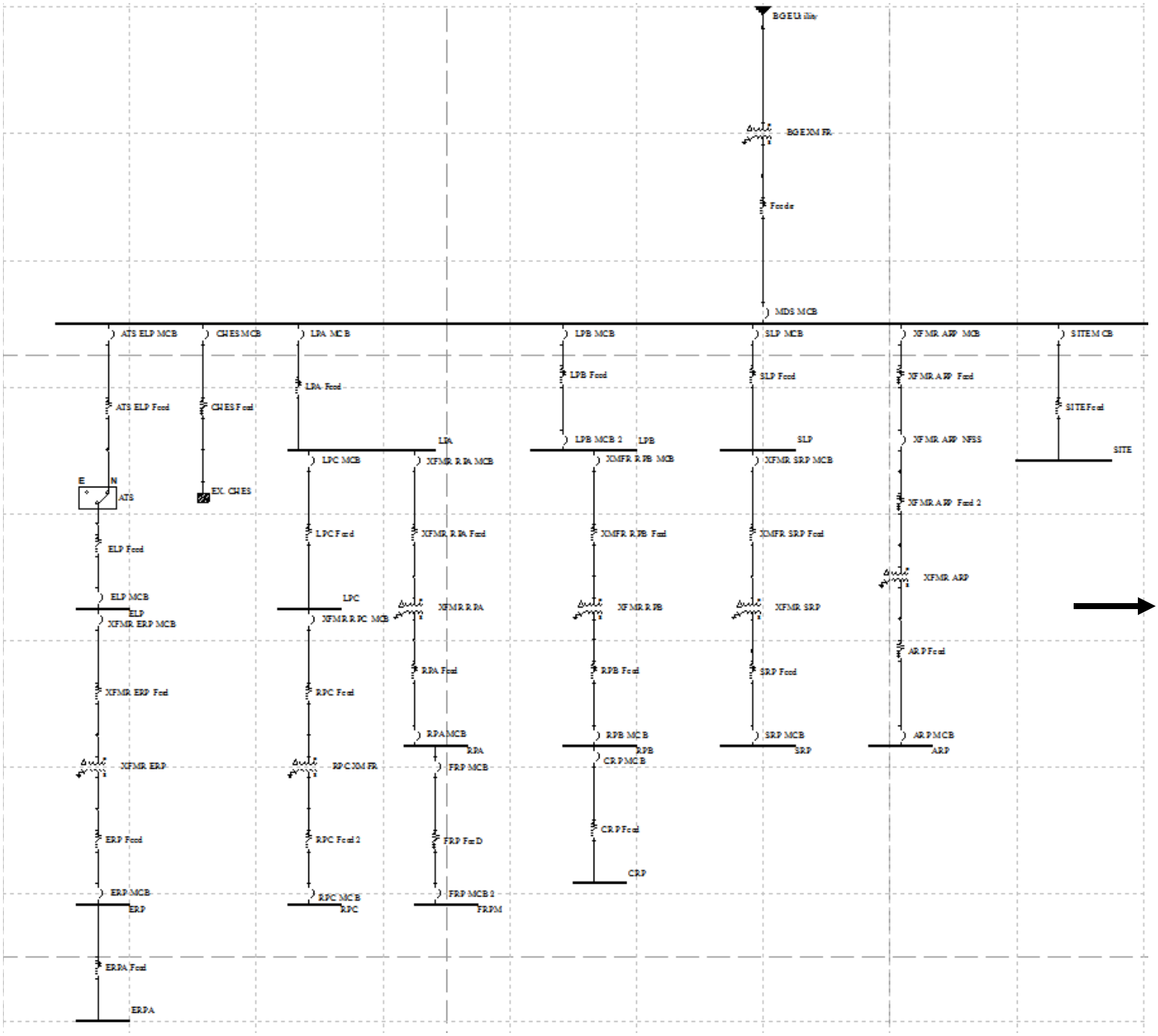
Drawing 16. Mechanical Room Floor Plan

Electrical Depth 2– SKM Analysis

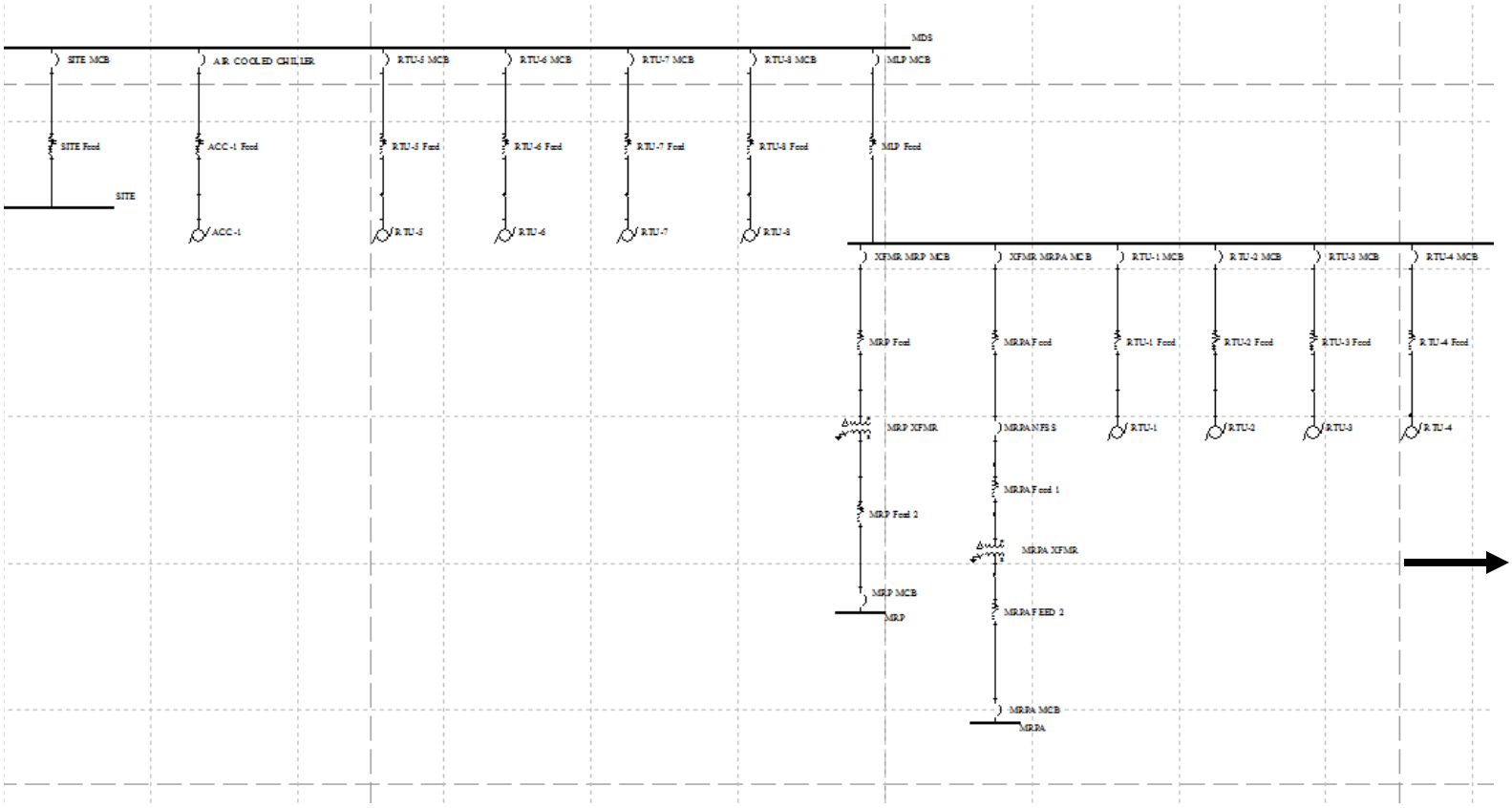
Description

This depth will use the Electrical Engineering Software known as SKM Power Tool Analysis. This program allows the user to input the main electrical components of the electrical system and run an extensive study on the equipment. This study includes short circuit analysis and arc fault studies. The model used for this analysis was based off of the riser diagram used in Tech Report II and includes all motors listed in the Motor Control Center in Electrical Depth 1. The following tables and screen shots from the program will show further details on the model and analysis completed.

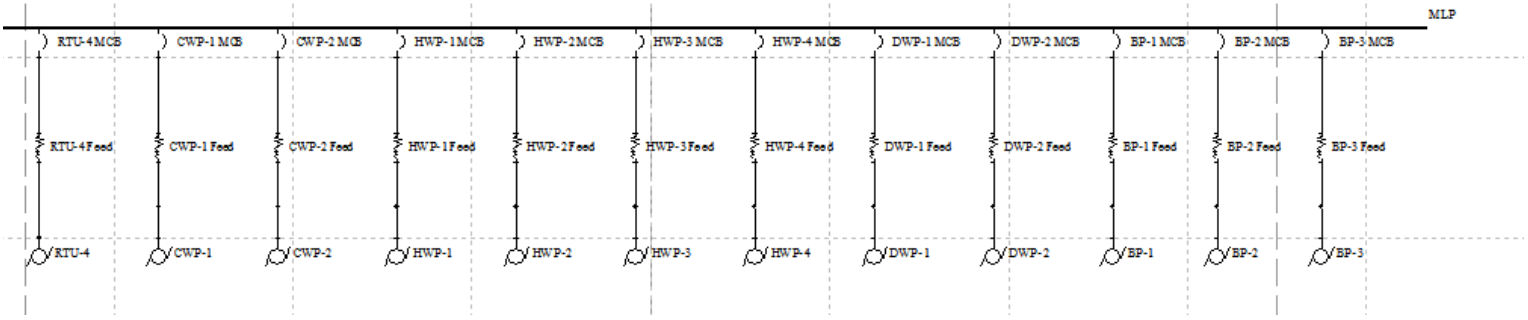
Riser Model



Drawing 17. SKM Riser Diagram Part I



Drawing 18. SKM Riser Diagram Part II



Drawing 19. SKM Riser Diagram Part III

Short Circuit Analysis

Bus Name	Voltage (L-L)	kAIC Rating	3-Phase (A)	X/R	Line/ Ground (A)	X/R	Protected
MDS	480	65	27,975	6.1	31,243	5.5	Yes
MLP	480	35	26,956	5.2	29,153	4.2	Yes
LPA	480	25	24,149	3.4	24,247	2.4	Yes
LPB	480	25	17,571	1.7	14,498	1.1	Yes
LPC	480	14	5,776	0.5	3,576	0.3	Yes
ELP	480	25	23,719	2.2	22,580	1.4	Yes
SLP	480	14	6,437	0.4	3,963	0.3	Yes
SITE	480	25	17,571	1.7	14.498	1.1	Yes
MRP	208	10	3,059	1.6	3,078	1.6	Yes
MRPA	208	10	1,649	0.7	1,676	0.6	Yes
RPA	208	35	6,907	1.6	7,054	1.5	Yes
RPB	208	35	3,008	1.7	3,044	1.6	Yes
RPC	208	10	1,588	0.6	1633	0.6	Yes
FRP	208	10	3,617	0.7	2,649	0.5	Yes
CRP	208	10	2,135	0.9	1,751	0.7	Yes
ARP	208	35	8,797	2.4	9,519	2.4	Yes
ERP	208	10	1,751	0.7	1,744	0.7	Yes
ERPA	208	10	1,741	0.7	1,728	0.7	Yes

Table 38. SKM Fault Analysis

Data Summary

The Short Circuit Study conducted by SKM illustrated that the specified fault current bus ratings on the equipment are higher than the simulated fault currents. This means that in the unlikely event of a fault, the equipment will not explode or create further damage to the system. There is, however, one section that draws attention and that is Panel LPA. Panel LPA's fault current bus rating is 25,000A, which is very near the simulated fault current that SKM is predicting could happen at this Panel. This may require Panel LPA to increase it's rating to a higher one of 35,000A.

Arc Flash Evaluation

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report Project: Susquehanna Center, Base Project

	Bus Name	Protective Device 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 #
1	ARP	ARP MCB	0.208	8.80	3.38	8.80	3.38	2	0.000	Yes	PNL	25	101	18	20	Category 3 (*N3) (*N9)	# 0001
2																	
3	CRP	CRP MCB	0.208	2.14	1.47	2.14	1.47	2	0.000	Yes	PNL	25	59	18	8.3	Category 3 (*N9)	# 0002
4																	
5	ELP	ELP MCB	0.48	23.72	13.71	23.72	13.71	0.013	0.000	Yes	PNL	25	12	18	0.61	Category 0	# 0003
6																	
7	ERP	ERP MCB	0.208	1.75	1.28	1.75	1.28	2	0.000	Yes	PNL	25	54	18	7.2	Category 2 (*N9)	# 0004
8																	
9	ERPA	ERP MCB	0.208	1.74	1.27	1.74	1.27	2	0.000	Yes	PNL	25	54	18	7.1	Category 2 (*N9)	# 0005
10																	
11	FRPM	FRP MCB 2	0.208	3.62	2.13	3.62	2.13	0.02	0.000	Yes	PNL	25	5	18	0.12	Category 0	# 0006
12																	
13	LPA	LPA MCB	0.48	24.15	13.93	24.15	13.93	0.01	0.000	Yes	PNL	25	10	18	0.47	Category 0	# 0007
14																	
15	LPB	LPB MCB	0.48	17.57	10.61	17.57	10.61	0.01	0.000	Yes	PNL	25	9	18	0.35	Category 0	# 0008
16																	
17	LPC	LPC MCB	0.48	5.78	4.10	5.78	4.10	0.016	0.000	Yes	PNL	25	6	18	0.20	Category 0	# 0009
18																	
19	MDS	AIR COOLED CHILLER	0.48	27.98	14.84	2.27	1.20	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
20	MDS	MLP MCB	0.48	27.98	14.84	1.95	1.03	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
21	MDS	RTU-5 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
22	MDS	RTU-6 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
23	MDS	RTU-7 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
24	MDS	RTU-8 MCB	0.48	27.98	14.84	0.21	0.11	0.083	0.000	Yes	SWG	32	42	24	2.7	Category 1 (*N2)	
25	MDS	MaxTripTime @2.0s	0.48	27.98	14.84	22.92	12.57	2	0.000	Yes	SWG	32	321	24	54	Dangerous! (*N2) (*N9)	# 0010
26																	
27	MLP	MLP MCB	0.48	26.96	15.30	25.01	14.19	0.019	0.000	Yes	PNL	25	16	18	1.00	Category 0	# 0011

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Table 39. SKM Arc Flash Analysis Part I

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report   Project: Susquehanna Center, Base Project

	Bus Name	Protective Device 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 #
28	MLP	BP-1 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
29	MLP	BP-2 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
30	MLP	BP-3 MCB	0.48	26.96	15.30	0.02	0.01	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
31	MLP	CWP-1 MCB	0.48	26.96	15.30	0.31	0.17	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
32	MLP	CWP-2 MCB	0.48	26.96	15.30	0.31	0.17	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
33	MLP	DWP-1 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
34	MLP	DWP-2 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
35	MLP	HWP-1 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
36	MLP	HWP-2 MCB	0.48	26.96	15.30	0.06	0.03	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
37	MLP	HWP-3 MCB	0.48	26.96	15.30	0.23	0.13	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
38	MLP	HWP-4 MCB	0.48	26.96	15.30	0.23	0.13	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
39	MLP	RTU-1 MCB	0.48	26.96	15.30	0.12	0.07	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
40	MLP	RTU-2 MCB	0.48	26.96	15.30	0.15	0.09	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
41	MLP	RTU-3 MCB	0.48	26.96	15.30	0.19	0.11	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
42	MLP	RTU-4 MCB	0.48	26.96	15.30	0.12	0.07	0.083	0.000	Yes	PNL	25	19	18	1.3	Category 1	
43																	
44	MRP	XFMR MRP MCB	0.208	3.06	1.61	3.06	1.61	1.115	0.000	Yes	PNL	25	44	18	5.1	Category 2 (*N3)	# 0012
45																	
46	MRPA	MRPA MCB	0.208	1.65	1.04	1.65	1.04	2	0.000	Yes	PNL	25	47	18	5.7	Category 2 (*N3) (*N9)	# 0013
47																	
48	RPA	RPA MCB	0.208	6.91	2.85	6.91	2.85	1.894	0.000	Yes	PNL	25	87	18	16	Category 3 (*N3)	# 0014
49																	
50	RPB	RPB MCB	0.208	3.01	1.87	3.01	1.87	1.965	0.000	Yes	PNL	25	68	18	11	Category 3	# 0015
51																	
52	RPC	RPC MCB	0.208	1.59	1.19	1.59	1.19	2	0.000	Yes	PNL	25	51	18	6.7	Category 2 (*N9)	# 0016
53																	
54	SITE	SITE MCB	0.48	17.57	10.61	17.57	10.61	0.012	0.000	Yes	PNL	25	10	18	0.43	Category 0	# 0017
55																	

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Table 40. SKM Arc Flash Analysis Part II

Arc Flash Evaluation Arc Flash Evaluation IEEE 1584 - 2002/2004a Edition Bus Report Project: Susquehanna Center, Base Project

	Bus Name	Protective Device 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 #
56	SLP	SLP MCB	0.48	6.44	4.50	6.44	4.50	0.01	0.000	Yes	PNL	25	5	18	0.14	Category 0	# 0018
57																	
58	SRP	SRP MCB	0.208	1.61	1.21	1.61	1.21	2	0.000	Yes	PNL	25	52	18	6.7	Category 2 (*N9)	# 0019
59																	
60	Category 0: Nonmelting, Flammable Materials with Weight >= 4.5 oz/sq yd	0.0 - 1.2 cal/cm^2													#Cat 0 = 8	(*N2) < 80% Cleared Fault Threshold	
61	Category 1: Arc-rated FR Shirt & Pants	1.2 - 4.0 cal/cm^2													#Cat 1 = 0	(*N3) - Arcing Current Low Tolerances Used	
62	Category 2: Arc-rated FR Shirt & Pants	4.0 - 8.0 cal/cm^2													#Cat 2 = 6	(*N9) - Max Arcing Duration Reached	
63	Category 3: Arc-rated FR Shirt & Pants & Arc Flash Suit	8.0 - 25.0 cal/cm^2													#Cat 3 = 4		
64	Category 4: Arc-rated FR Shirt & Pants & Arc Flash Suit	25.0 - 40.0 cal/cm^2													#Cat 4 = 0		
65	Category Dangerous!: No FR Category Found	Device with 80% Cleared Fault Threshold													#Danger = 1	IEEE 1584 - 2002/2004a Edition Bus Report (80% Cleared Fault Threshold, include Ind. Motors for 5.0 Cycles), mis-coordination not checked	

Table 41. SKM Arc Flash Analysis Part III

Data Summary

The Arc Flash Evaluation conducted by SKM demonstrated that most of protective devices fell into the appropriate category of protection. The main gear and higher ampacity Panels attained higher Personal Protective Equipment (PPE) ratings than Panels of smaller ampacity. One area of interest is the Main Switchboard, MDS, in which the rating was Dangerous, the highest possible rating, meaning that working on this piece of gear is of extreme hazard and no PPE clothing can protect you. This should raise a red flag and further analysis of this section needs to be conducted to further illustrate the effects.