Electrical Depth

Electrical Introduction

The current power distribution system provides the building with power; however, an alternative design solution was analyzed. This analysis was done in order to compare the two different systems by cost analysis, efficiency, and power consumption.

The system redesign is comprised of a variety of different tasks, which include the redesign of branch circuits for the four re-lighted spaces, analysis of a central transformer versus distributed transformers, analysis of feeders versus a bus duct spanning to the penthouse, the analysis of a motor control center, and a protective device coordination study. The redesign of the power distribution system was compared to the existing system regarding cost analysis, efficiency, and power consumption. The cost analysis is a part of the construction management breadth work.

The power distribution system was redesigned following the 2005 NEC handbook. The branch circuits were recalculated along with feeders and panelboard schedules for all four areas of the redesign of the lighting systems. A central transformer was utilized instead of distributed transformers on each floor. The elimination of a variety of feeders in place of a bus duct spanning to the penthouse should be an advantageous change to the power distribution system. The installment of a mechanical equipment motor control center was analyzed by calculating the design loads for branch conductors, feeders, and protective devices. Also, a short circuit current calculation was investigated for a single-path through the distribution system.

Branch Circuit Redesign – Plaza

Original Panelboard 1LA - Plaza

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
1LA	VOLTAGE	120/208			BUSS			150A				FROM	1DPA
MOUNTING: SURFACE	PHASE	3			MAIN/MLO			MLO				TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING			10 kA				SIZE	SEE RISER ON E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
RCPT 112	900	12		20A-1P	1	A----	2	20A-1P		12	500	RELAY PANEL LP-1	
RCPT 110	180	12		20A-1P	3	--B--	4	20A-1P		12	1080	RCPT 112B	
RCPT 110	540	12		20A-1P	5	---C	6	20A-1P		12	100	UH LOADING DOCK	
GFI WP	360	12		20A-1P	7	A----	8	20A-1P		12	1000	PLASMA SCREEN	
RCPT 100,100C,111	900	12		20A-1P	9	--B--	10	20A-1P				*SPARE*	
COLUMN RCPT 100	720	12		20A-1P	11	---C	12	20A-1P		12	360	EXTERIOR AND DOCK GUARD	
COLUMN RCPT 100	720	12		20A-1P	13	A----	14	20A-1P		12	200	EXTERIOR CAMERA	
ICE MACHINE	1000	12		20A-1P	15	--B--	16	20A-1P		12	500	COFFEE	
GARBAGE DISPOSAL	1000	12		20A-1P	17	---C	18	20A-1P		12	1500	FOOD CARTS	
REFRIGERATOR	1000	12		20A-1P	19	A----	20	20A-1P		12	1500	FOOD CARTS	
DISHWASHER, 110	6126	#3	1.25"	80A-2P	21	--B--	22	20A-1P				*SPARE*	
	6126				23	---C	24	20A-1P				*SPARE*	
RCPT METERS, 112A	500	12		20A-1P	25	A----	26	20A-1P				SPARE	
SPACE AND PROVISION					27	--B--	28					SPACE AND PROVISION	
SPACE AND PROVISION					29	---C	30					SPACE AND PROVISION	
SPACE AND PROVISION					31	A----	32					SPACE AND PROVISION	
SPACE AND PROVISION					33	--B--	34					SPACE AND PROVISION	
SPACE AND PROVISION					35	---C	36					SPACE AND PROVISION	
AUTO DOOR, 112	829	12		20A-3P	37	A----	38					SPACE AND PROVISION	
	829				39	--B--	40					SPACE AND PROVISION	
	829				41	---C	42					SPACE AND PROVISION	

NOTES:
1. PROVIDE 200% NEUTRAL

Figure 30: Original Panelboard – Plaza

New Panelboard 1LA – Plaza

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 150A
SIZE/TYPE MAIN: 150A/3P C/B

PANEL TAG: 1LA
PANEL LOCATION: Room 112B - Electrical Room
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1DPA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
RCPT	Room 112	900	20A/1P	1	*			2	20A/1P	500	-	RELAY PANEL LP-1
RCPT	Room 110	180	20A/1P	3		*		4	20A/1P	1080	Room 112B	RCPT
RCPT	Room 110	540	20A/1P	5			*	6	20A/1P	100	-	UH LOADING DOCK
GFI WP	-	360	20A/1P	7	*			8	20A/1P	1000	-	PLASMA SCREEN
RCPT	Rm 100, 111	900	20A/1P	9		*		10	20A/1P	0	-	SPARE
COLUMN RCPT	Room 100	720	20A/1P	11			*	12	20A/1P	0	-	SPARE
COLUMN RCPT	Room 100	720	20A/1P	13	*			14	20A/1P	200	-	EXT. CAMERA
ICE MACHINE	-	1000	20A/1P	15		*		16	20A/1P	500	-	COFFEE
GARBAGE DISPOSA	-	1000	20A/1P	17			*	18	20A/1P	1500	-	FOOD CARTS
REFRIGERATOR	-	1000	20A/1P	19	*			20	20A/1P	1500	-	FOOD CARTS
DISHWASHER	-	6126	80A/2P	21		*		22	20A/1P	0	-	SPARE
DISHWASHER	-	6126	80A/2P	23			*	24	20A/1P	0	-	SPARE
RCPT METERS	Room 112A	500	20A/1P	25	*			26	20A/1P	0	-	SPARE
SPACE & PROV.	-	0		27		*		28		0	-	SPACE & PROV.
SPACE & PROV.	-	0		29			*	30		0	-	SPACE & PROV.
SPACE & PROV.	-	0		31	*			32		0	-	SPACE & PROV.
SPACE & PROV.	-	0		33		*		34		0	-	SPACE & PROV.
SPACE & PROV.	-	0		35			*	36		0	-	SPACE & PROV.
AUTO DOOR	Room 112	829	20A/3P	37	*			38		0	-	SPACE & PROV.
AUTO DOOR	Room 112	829	20A/3P	39		*		40		0	-	SPACE & PROV.
AUTO DOOR	Room 112	829	20A/3P	41			*	42		0	-	SPACE & PROV.

CONNECTED LOAD (KW) - A	7.51	TOTAL DESIGN LOAD (KW)	24.55
CONNECTED LOAD (KW) - B	10.62	POWER FACTOR	0.88
CONNECTED LOAD (KW) - C	10.82	TOTAL DESIGN LOAD (AMPS)	77

Figure 31: New Panelboard – Plaza

Feeder Size – Plaza

Feeder Size – Panelboard 1LA	
Calculated Design Load	77.4 A
Feeder Protection Size	80 A
Sets	1
Wire Size	
Phase	#4 AWG
Neutral	2/0 AWG
Ground	#8 AWG
Wire Area	
Each Phase	0.0824"
All Phase	0.2472"
Neutral	0.2223"
Ground	0.0366"
Total Area	0.5061"
Conduit Size	1 ¼"
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 200% Neutral

Table 21: Feeder Size – Plaza

Original Panelboard 1HA - Plaza

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
1HA	VOLTAGE	277/480			BUSS			200A				FROM	BDPA
SURFACE	PHASE	3			MAIN/MLO			MLO W/SUBFEED LUGS				TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING			25 kA				SIZE	SEE RISER ON E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
LIGHTING	2776	12		20A-1P	1	A----	2	20A-1P		#12	1300	SITE LGT. WEST PLAZA	
LIGHTING	2648	12		20A-1P	3	--B--	4	20A-1P		#12	800	TREE LGT. WEST PLAZA	
LIGHTING	2960	12		20A-1P	5	---C	6	20A-1P		#12	1295	SITE LGT @ SCOTT	
LIGHTING	1824	12		20A-1P	7	A----	8				5466		
LIGHTING	1710	12		20A-1P	9	--B--	10	50A-3P	1"	#6	5466	PANEL DP1	
LIGHTING	3162	12		20A-1P	11	---C	12				5466		
VAV'S	2424	#12		20A-1P	13	A----	14	20A-1P		#12	1780	SITE LGT. EAST PLAZA	
VAV'S	1224	#12		20A-1P	15	--B--	16	20A-1P		#12	1300	TREE LGT. EAST PLAZA	
PARK SIGNS	*2200*	#12		20A-1P	17	---C	18	20A-1P				SPARE	
SPARE				20A-1P	19	A----	20	20A-1P				SPARE	
SPARE				20A-1P	21	--B--	22	20A-1P				SPARE	
SPARE				20A-1P	23	---C	24	20A-1P				SPARE	
SPARE				20A-1P	25	A----	26	20A-1P				SPARE	
SPARE				20A-1P	27	--B--	28	20A-1P				SPARE	
SPARE				20A-1P	29	---C	30	20A-1P				SPARE	
SPACE AND PROVISION					31	A----	32					SPACE AND PROVISION	
SPACE AND PROVISION					33	--B--	34					SPACE AND PROVISION	
SPACE AND PROVISION					35	---C	36					SPACE AND PROVISION	
SPACE AND PROVISION					37	A----	38					SPACE AND PROVISION	
SPACE AND PROVISION					39	--B--	40					SPACE AND PROVISION	
SPACE AND PROVISION					41	---C	42					SPACE AND PROVISION	
NOTES:													

Figure 32: Original Panelboard – Plaza

New Panelboard 1HA – Plaza

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 200A
SIZE/TYPE MAIN: 200A/3P C/B

PANEL TAG: 1HA
PANEL LOCATION: Room 112B - Electrical Room
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 25K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD BDPA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LIGHTING	-	2776	20A/1P	1	*			2	20A/1P	1400	Plaza	LIGHTING
LIGHTING	-	2648	20A/1P	3		*		4	20A/1P	2808	Plaza	LIGHTING
LIGHTING	-	2960	20A/1P	5			*	6	20A/1P	1146	Plaza	LIGHTING
LIGHTING	-	1824	20A/1P	7	*			8	50A/3P	5466	-	PANEL DP1
LIGHTING	-	1710	20A/1P	9		*		10	50A/3P	5466	-	PANEL DP1
LIGHTING	-	3162	20A/1P	11			*	12	50A/3P	5466	-	PANEL DP1
VAV'S	-	2424	20A/1P	13	*			14	20A/1P	924	Plaza	LIGHTING
VAV'S	-	1224	20A/1P	15		*		16	20A/1P	1260	Plaza	LIGHTING
PARK SIGNS	-	2200	20A/1P	17			*	18	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	19	*			20	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	21		*		22	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	23			*	24	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	25	*			26	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	27		*		28	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	29			*	30	20A/1P	0	-	SPARE
SPACE & PROV.	-	0		31	*			32		0	-	SPACE & PROV.
SPACE & PROV.	-	0		33		*		34		0	-	SPACE & PROV.
SPACE & PROV.	-	0		35			*	36		0	-	SPACE & PROV.
SPACE & PROV.	-	0		37	*			38		0	-	SPACE & PROV.
SPACE & PROV.	-	0		39		*		40		0	-	SPACE & PROV.
SPACE & PROV.	-	0		41			*	42		0	-	SPACE & PROV.

CONNECTED LOAD (KW) - A	14.81	TOTAL DESIGN LOAD (KW)	34.67
CONNECTED LOAD (KW) - B	15.12	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	14.93	TOTAL DESIGN LOAD (AMPS)	44

Figure 33: New Panelboard – Plaza

Feeder Size – Plaza

Feeder Size – Panelboard 1HA	
Calculated Design Load	44.1 A
Feeder Protection Size	45 A
Sets	1
Wire Size	
Phase	#8 AWG
Neutral	#8 AWG
Ground	#10 AWG
Wire Area	
Each Phase	0.0366"
All Phase	0.1098"
Neutral	0.0366"
Ground	0.0211"
Total Area	0.1675"
Conduit Size	¾"
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral

Table 22: Feeder Size – Plaza

Branch Circuit Redesign – Lobby

Original Panelboard - Lobby

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION						FEEDER INFORMATION	
DP1	VOLTAGE	277/480			BUSS			125A			FROM	1HA
MOUNTING: SURFACE	PHASE	3			MAIN/MLO			MLO W/SUBFEED LUGS			TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING			14 kA			SIZE	SEE RISER E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM
LOBBY ZONE 1	420	#12		20A-1P	1	A----	2	20A-1P		#12	240	LOBBY ZONE 9
LOBBY ZONE 2	2760	#12		20A-1P	3	--B--	4	20A-1P		#12	240	LOBBY ZONE 10
LOBBY ZONE 3	480	#12		20A-1P	5	---C	6	20A-1P		#12	2240	AUDITORIUM ZONE 11
LOBBY ZONE 4	1200	#12		20A-1P	7	A----	8	20A-1P		#12	1088	AUDITORIUM ZONE 12
LOBBY ZONE 5	450	#12		20A-1P	9	--B--	10	20A-1P		#12	1500	AUDITORIUM ZONE 13
LOBBY ZONE 6	810	#12		20A-1P	11	---C	12	20A-1P		#12	900	AUDITORIUM ZONE 14
LOBBY ZONE 7	400	#12		20A-1P	13	A----	14	20A-1P		#12	300	AUDITORIUM ZONE 15
LOBBY ZONE 8	660	#12		20A-1P	15	--B--	16	20A-1P		#12	300	AUDITORIUM ZONE 16

NOTES:
1. DIMMING PANEL PROVIDED WITH DIMMING SYSTEM.

Figure 34: Original Panelboard – Lobby

New Panelboard – Lobby

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: DP1	MIN. C/B AIC: 14 K
SIZE/TYPE BUS: 125A	PANEL LOCATION: ROOM 112B - ELECTRICAL	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 125A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1HA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LIGHTING ZONE 1	Lobby	2240	20A/1P	1	*			2	20A/1P	216	Lobby	LIGHTING ZONE 8
LIGHTING ZONE 2	Lobby	432	20A/1P	3		*		4	20A/1P	2240	Auditorium	LIGHTING ZONE 11
LIGHTING ZONE 3	Lobby	896	20A/1P	5			*	6	20A/1P	1088	Auditorium	LIGHTING ZONE 12
LIGHTING ZONE 4	Lobby	216	20A/1P	7	*			8	20A/1P	1500	Auditorium	LIGHTING ZONE 13
LIGHTING ZONE 5	Lobby	432	20A/1P	9		*		10	20A/1P	900	Auditorium	LIGHTING ZONE 14
LIGHTING ZONE 6	Lobby	432	20A/1P	11			*	12	20A/1P	300	Auditorium	LIGHTING ZONE 15
LIGHTING ZONE 7	Lobby	432	20A/1P	13	*			14	20A/1P	300	Auditorium	LIGHTING ZONE 16
		0		15		*		16		0		
		0		17			*	18		0		
		0		19	*			20		0		
		0		21		*		22		0		
		0		23			*	24		0		
		0		25	*			26		0		
		0		27		*		28		0		
		0		29			*	30		0		
		0		31	*			32		0		
		0		33		*		34		0		
		0		35			*	36		0		
		0		37	*			38		0		
		0		39		*		40		0		
		0		41			*	42		0		

CONNECTED LOAD (KW) - A	4.90	TOTAL DESIGN LOAD (KW)	13.95
CONNECTED LOAD (KW) - B	4.00	POWER FACTOR	0.96
CONNECTED LOAD (KW) - C	2.72	TOTAL DESIGN LOAD (AMPS)	18

Figure 35: New Panelboard – Lobby

Feeder Size – Lobby

Feeder Size – Panelboard DP1	
Calculated Design Load	17.6 A
Feeder Protection Size	20 A
Sets	1
Wire Size	
Phase	#12 AWG
Neutral	#12 AWG
Ground	#12 AWG
Wire Area	
Each Phase	0.0133"
All Phase	0.0399"
Neutral	0.0133"
Ground	0.0133"
Total Area	0.0665"
Conduit Size	¾"
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral

Table 23: Feeder Size Lobby

Original Panelboard – Lobby

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
1LD	VOLTAGE	120/208			BUSS			100A				FROM	1DPA
MOUNTING: SURFACE	PHASE	3			MAIN/MLO			MLO				TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING			10 kA				SIZE	SEE RISER ON E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS		LOCATION/ITEM
COLUMN RECEPTS	1440	12		20A-1P	1	A----	2	20A-1P		12	900		WIREWAY: LOBBY
COLUMN RECEPTS	1440	12		20A-1P	3	--B--	4	20A-1P		12	720		WIREWAY: LOBBY
PROJECTOR: LOBBY	1000	12		20A-1P	5	---C	6	20A-1P		12	540		RECEPTS
MOTORIZED SCREEN	500	12		20A-1P	7	A----	8	20A-1P		12	500		SENSORS: RESTROOM
A V EQUIPMENT	1000	12		20A-1P	9	--B--	10	20A-1P		12	500		SENSORS: RESTROOM
PLASMA SCREEN	*1000*	12		20A-1P	11	---C	12	20A-1P		12	540		RESTROOM GFI
PLASMA SCREEN	1000	12		20A-1P	13	A----	14	20A-1P		12	250		LUTRON SYSTEM, 100
EWC GFI	500	12		20A-1P	15	--B--	16	20A-1P		12	1395		FCU'S, 100A
EWC GFI	500	12		20A-1P	17	---C	18	20A-1P		12	540		RCPT, 101
ELEVATOR PIT	540	12		20A-1P	19	A----	20	20A-1P		*12*	*1000*		*PLASMA SCREEN*
SPARE				20A-1P	21	--B--	22						SPACE AND PROVISION
SPARE				20A-1P	23	---C	24						SPACE AND PROVISION
SPARE				20A-1P	25	A----	26						SPACE AND PROVISION
SPACE AND PROVISION					27	--B--	28						SPACE AND PROVISION
SPACE AND PROVISION					29	---C	30						SPACE AND PROVISION
SPACE AND PROVISION					31	A----	32						SPACE AND PROVISION
SPACE AND PROVISION					33	--B--	34						SPACE AND PROVISION
SPACE AND PROVISION					35	---C	36						SPACE AND PROVISION
SPACE AND PROVISION					37	A----	38						SPACE AND PROVISION
SPACE AND PROVISION					39	--B--	40						SPACE AND PROVISION
SPACE AND PROVISION					41	---C	42						SPACE AND PROVISION

NOTES:
1. PROVIDE 200% NEUTRAL

Figure 36: Original Panelboard – Lobby

New Panelboard – Lobby

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 100A
SIZE/TYPE MAIN: 100A/3P C/B

PANEL TAG: 1LD
PANEL LOCATION: ROOM 112B - ELECTRICAL
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 10K
OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1DPA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
COLUMN RCPTS	LOBBY	1440	20A/1P	1	*			2	20A/1P	900	LOBBY	WIREWAY: LOBBY
COLUMN RCPTS	LOBBY	1440	20A/1P	3		*		4	20A/1P	720	LOBBY	WIREWAY: LOBBY
ROJECTOR: LOBBY	LOBBY	1000	20A/1P	5			*	6	20A/1P	540	-	RECEPTS
OTORIZED SCREE	LOBBY	500	20A/1P	7	*			8	20A/1P	500	-	SENSORS: RR
AV EQUIPMENT	LOBBY	1000	20A/1P	9		*		10	20A/1P	500	-	SENSORS: RR
PLASMA SCREEN	LOBBY	1000	20A/1P	11			*	12	20A/1P	540	-	RESTROOM GFI
PLASMA SCREEN	LOBBY	1000	20A/1P	13	*			14	20A/1P	250	100	LUTRON SYSTEM
EWC GFI	LOBBY	500	20A/1P	15		*		16	20A/1P	1395	100A	FCU'S
EWC GFI	LOBBY	500	20A/1P	17			*	18	20A/1P	540	100	RCPT
ELEVATOR PIT	LOBBY	540	20A/1P	19	*			20	20A/1P	1000	LOBBY	PLASMA SCREEN
LIGHTING ZONE 9	LOBBY	1200	20A/1P	21		*		22	20A/1P	0	-	SPACE & PROV
LIGHTING ZONE 10	LOBBY	450	20A/1P	23			*	24	20A/1P	0	-	SPACE & PROV
SPARE	-	0	20A/1P	25	*			26	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	27		*		28	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	29			*	30	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	31	*			32	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	33		*		34	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	35			*	36	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	37	*			38	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	39		*		40	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	41			*	42	20A/1P	0	-	SPACE & PROV

CONNECTED LOAD (KW) - A	6.13	TOTAL DESIGN LOAD (KW)	19.40
CONNECTED LOAD (KW) - B	6.76	POWER FACTOR	0.90
CONNECTED LOAD (KW) - C	4.57	TOTAL DESIGN LOAD (AMPS)	60

Figure 37: New Panelboard – Lobby

Feeder Size – Lobby

Feeder Size – Panelboard 1LD	
Calculated Design Load	59.8 A
Feeder Protection Size	60 A
Sets	1
Wire Size	
Phase	#6 AWG
Neutral	#6 AWG
Ground	#10 AWG
Wire Area	
Each Phase	0.0507"
All Phase	0.1521"
Neutral	0.0507"
Ground	0.0211"
Total Area	0.2239"
Conduit Size	¾"
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral

Table 24: Feeder Size Lobby

Branch Circuit Redesign – Auditorium

Original Panelboard - Auditorium

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
DP1	VOLTAGE	277/480			BUSS			125A				FROM	1HA
MOUNTING: SURFACE	PHASE	3			MAIN/MLO			MLO W/SUBFEED LUGS				TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING			14 kA				SIZE	SEE RISER E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
LOBBY ZONE 1	420	#12		20A-1P	1	A----	2	20A-1P		#12	240	LOBBY ZONE 9	
LOBBY ZONE 2	2760	#12		20A-1P	3	--B--	4	20A-1P		#12	240	LOBBY ZONE 10	
LOBBY ZONE 3	480	#12		20A-1P	5	---C	6	20A-1P		#12	2240	AUDITORIUM ZONE 11	
LOBBY ZONE 4	1200	#12		20A-1P	7	A----	8	20A-1P		#12	1088	AUDITORIUM ZONE 12	
LOBBY ZONE 5	450	#12		20A-1P	9	--B--	10	20A-1P		#12	1500	AUDITORIUM ZONE 13	
LOBBY ZONE 6	810	#12		20A-1P	11	---C	12	20A-1P		#12	900	AUDITORIUM ZONE 14	
LOBBY ZONE 7	400	#12		20A-1P	13	A----	14	20A-1P		#12	300	AUDITORIUM ZONE 15	
LOBBY ZONE 8	660	#12		20A-1P	15	--B--	16	20A-1P		#12	300	AUDITORIUM ZONE 16	

NOTES:
1. DIMMING PANEL PROVIDED WITH DIMMING SYSTEM.

Figure 38: Original Panelboard – Auditorium

New Panelboard – Auditorium

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: DP1	MIN. C/B AIC: 14 K
SIZE/TYPE BUS: 125A	PANEL LOCATION: Room 112B - Electrical	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 125A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 1HA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LIGHTING ZONE 1	Lobby	2240	20A/1P	1	*			2	20A/1P	216	Lobby	LIGHTING ZONE 8
LIGHTING ZONE 2	Lobby	432	20A/1P	3		*		4	20A/1P	1200	Auditorium	LIGHTING ZONE 11
LIGHTING ZONE 3	Lobby	896	20A/1P	5			*	6	20A/1P	1800	Auditorium	LIGHTING ZONE 12
LIGHTING ZONE 4	Lobby	216	20A/1P	7	*			8	20A/1P	500	Auditorium	LIGHTING ZONE 13
LIGHTING ZONE 5	Lobby	432	20A/1P	9		*		10	20A/1P	567	Auditorium	LIGHTING ZONE 14
LIGHTING ZONE 6	Lobby	432	20A/1P	11			*	12	20A/1P	0	-	SPARE
LIGHTING ZONE 7	Lobby	432	20A/1P	13	*			14	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	15		*		16	20A/1P	0	-	SPARE
	-	0		17			*	18		0	-	
	-	0		19	*			20		0	-	
	-	0		21		*		22		0	-	
	-	0		23			*	24		0	-	
	-	0		25	*			26		0	-	
	-	0		27		*		28		0	-	
	-	0		29			*	30		0	-	
	-	0		31	*			32		0	-	
	-	0		33		*		34		0	-	
	-	0		35			*	36		0	-	
	-	0		37	*			38		0	-	
	-	0		39		*		40		0	-	
	-	0		41			*	42		0	-	

CONNECTED LOAD (KW) - A	3.60	TOTAL DESIGN LOAD (KW)	11.24
CONNECTED LOAD (KW) - B	2.63	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	3.13	TOTAL DESIGN LOAD (AMPS)	14

Figure 39: New Panelboard – Auditorium

Feeder Size – Auditorium

Feeder Size – Panelboard DP1	
Calculated Design Load	14.3 A
Feeder Protection Size	15 A
Sets	1
Wire Size	
Phase	#12 AWG
Neutral	#12 AWG
Ground	#12 AWG
Wire Area	
Each Phase	0.0133"
All Phase	0.0399"
Neutral	0.0133"
Ground	0.0133"
Total Area	0.0665"
Conduit Size	¾"
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral

Table 25: Feeder Size Auditorium

Original Panelboard - Auditorium

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
DP2	VOLTAGE	277/480			BUSS		125A					FROM	DP1
MOUNTING: SURFACE	PHASE	3			MAIN/MLO		MLO					TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING		14 kA					SIZE	SEE RISER E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
AUDITORIUM ZONE 17	300	#12		20A-1P	1	A----	2	20A-1P		#12	150	AUDITORIUM ZONE 21	
AUDITORIUM ZONE 18	960	#12		20A-1P	3	--B--	4	20A-1P		#12	150	AUDITORIUM ZONE 22	
AUDITORIUM ZONE 19	300	#12		20A-1P	5	---C	6	20A-1P				SPARE	
AUDITORIUM ZONE 20	550	#12		20A-1P	7	A----	8	20A-1P				SPARE	

NOTES:
1. DIMMING PANEL PROVIDED WITH DIMMING SYSTEM.

Figure 40: Original Panelboard – Auditorium

New Panelboard – Auditorium

Some of the fixtures used in the auditorium were 208/120; therefore, the panelboard 1LD was utilized. The panelboard DP2 is unnecessary and will not be used.

Original Panelboard - Auditorium

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
1LD	VOLTAGE	120/208			BUSS		100A					FROM	1DPA
MOUNTING: SURFACE	PHASE	3			MAIN/MLO		MLO					TYPE	NORMAL
LOCATION: 1ST FLOOR	WIRE	4			AIC RATING		10 kA					SIZE	SEE RISER ON E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
COLUMN RECEPTS	1440	12		20A-1P	1	A----	2	20A-1P		12	900	WIREWAY: LOBBY	
COLUMN RECEPTS	1440	12		20A-1P	3	--B--	4	20A-1P		12	720	WIREWAY: LOBBY	
PROJECTOR: LOBBY	1000	12		20A-1P	5	---C	6	20A-1P		12	540	RECEPTS	
MOTORIZED SCREEN	500	12		20A-1P	7	A----	8	20A-1P		12	500	SENSORS: RESTROOM	
A V EQUIPMENT	1000	12		20A-1P	9	--B--	10	20A-1P		12	500	SENSORS: RESTROOM	
PLASMA SCREEN	*1000*	12		20A-1P	11	---C	12	20A-1P		12	540	RESTROOM GFI	
PLASMA SCREEN	1000	12		20A-1P	13	A----	14	20A-1P		12	250	LUTRON SYSTEM, 100	
EWC GFI	500	12		20A-1P	15	--B--	16	20A-1P		12	1395	FCU'S, 100A	
EWC GFI	500	12		20A-1P	17	---C	18	20A-1P		12	540	RCPT, 100	
ELEVATOR PIT	540	12		20A-1P	19	A----	20	20A-1P		*12*	*1000*	*PLASMA SCREEN*	
SPARE				20A-1P	21	--B--	22					SPACE AND PROVISION	
SPARE				20A-1P	23	---C	24					SPACE AND PROVISION	
SPARE				20A-1P	25	A----	26					SPACE AND PROVISION	
SPACE AND PROVISION					27	--B--	28					SPACE AND PROVISION	
SPACE AND PROVISION					29	---C	30					SPACE AND PROVISION	
SPACE AND PROVISION					31	A----	32					SPACE AND PROVISION	
SPACE AND PROVISION					33	--B--	34					SPACE AND PROVISION	
SPACE AND PROVISION					35	---C	36					SPACE AND PROVISION	
SPACE AND PROVISION					37	A----	38					SPACE AND PROVISION	
SPACE AND PROVISION					39	--B--	40					SPACE AND PROVISION	
SPACE AND PROVISION					41	---C	42					SPACE AND PROVISION	

NOTES:
1. PROVIDE 200% NEUTRAL

Figure 41: Original Panelboard – Auditorium

New Panelboard – Auditorium

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W	PANEL TAG: 1LD	MIN. C/B AIC: 10K
SIZE/TYPE BUS: 100A	PANEL LOCATION: ROOM 112B - ELECTRICAL	OPTIONS: SEE RISER ON E602
SIZE/TYPE MAIN: 100A/3P C/B	PANEL MOUNTING: SURFACE	

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
COLUMN RCPTS	LOBBY	1440	20A/1P	1	*			2	20A/1P	900	LOBBY	WIREWAY: LOBBY
COLUMN RCPTS	LOBBY	1440	20A/1P	3		*		4	20A/1P	720	LOBBY	WIREWAY: LOBBY
ROJECTOR: LOBB	LOBBY	1000	20A/1P	5			*	6	20A/1P	540	-	RECEPTS
OTORIZED SCREE	LOBBY	500	20A/1P	7	*			8	20A/1P	500	-	SENSORS: RR
AV EQUIPMENT	LOBBY	1000	20A/1P	9		*		10	20A/1P	500	-	SENSORS: RR
PLASMA SCREEN	LOBBY	1000	20A/1P	11			*	12	20A/1P	540	-	RESTROOM GFI
PLASMA SCREEN	LOBBY	1000	20A/1P	13	*			14	20A/1P	250	100	LUTRON SYSTEM
EWC GFI	LOBBY	500	20A/1P	15		*		16	20A/1P	1395	100A	FCU'S
EWC GFI	LOBBY	500	20A/1P	17			*	18	20A/1P	540	100	RCPT
ELEVATOR PIT	LOBBY	540	20A/1P	19	*			20	20A/1P	1000	LOBBY	PLASMA SCREEN
LIGHTING ZONE 9	LOBBY	1200	20A/1P	21		*		22	20A/1P	756	AUDITORIUM	LIGHTING ZONE 15
LIGHTING ZONE 10	LOBBY	450	20A/1P	23			*	24	20A/1P	756	AUDITORIUM	LIGHTING ZONE 16
LIGHTING ZONE 17	AUDITORIUM	756	20A/1P	25	*			26	20A/1P	1152	AUDITORIUM	LIGHTING ZONE 18
SPACE & PROV	-	0	20A/1P	27		*		28	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	29			*	30	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	31	*			32	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	33		*		34	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	35			*	36	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	37	*			38	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	39		*		40	20A/1P	0	-	SPACE & PROV
SPACE & PROV	-	0	20A/1P	41			*	42	20A/1P	0	-	SPACE & PROV

CONNECTED LOAD (KW) - A	8.04	TOTAL DESIGN LOAD (KW)	23.67
CONNECTED LOAD (KW) - B	7.51	POWER FACTOR	0.91
CONNECTED LOAD (KW) - C	5.33	TOTAL DESIGN LOAD (AMPS)	72

Figure 42: New Panelboard – Auditorium

Feeder Size – Auditorium

Feeder Size – Panelboard 1LD	
Calculated Design Load	72.3 A
Feeder Protection Size	80 A
Sets	1
Wire Size	
Phase	#4 AWG
Neutral	#4 AWG
Ground	#8 AWG
Wire Area	
Each Phase	0.0824”
All Phase	0.2472”
Neutral	0.0824”
Ground	0.0366”
Total Area	0.3662”
Conduit Size	1”
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾” conduit 100% Neutral

Table 26: Feeder Size Auditorium

Branch Circuit Redesign – Classroom

Original Panelboard - Classroom

PANEL NAME	VOLTAGE INFORMATION				PANEL INFORMATION							FEEDER INFORMATION	
5HA	VOLTAGE	277/480			BUSS			200A				FROM	4HA
SURFACE	PHASE	3			MAIN/MLO			MLO W/SUBFEED LUGS				TYPE	NORMAL
LOCATION OF PANEL	WIRE	4			AIC RATING			25 kA				SIZE	SEE RISER ON E602
LOCATION/ITEM	LOAD WATTS	WIRE	COND	BREAKER	CKT	PHS	CKT	BREAKER	COND	WIRE	LOAD WATTS	LOCATION/ITEM	
LIGHTING	2430	12		20-1P	1	A----	2	20A-1P		12	4008	VAV'S	
LIGHTING	2750	12		20-1P	3	--B--	4	20A-1P		12	2616	VAV'S	
LIGHTING	1650	12		20-1P	5	---C	6	20A-1P		12	2000	CORRIDOR LIGHTING	
LIGHTING	2462	12		20-1P	7	A----	8	20A-1P		12	2000	CORRIDOR LIGHTING	
LIGHTING	1884	12		20-1P	9	--B--	10	20A-1P				SPARE	
LIGHTING	2288	12		20-1P	11	---C	12	20A-1P				SPARE	
LIGHTING	1706	12		20-1P	13	A----	14	20A-1P				SPARE	
LIGHTING	2336	12		20-1P	15	--B--	16	20A-1P				SPARE	
SPARE				20A-1P	17	---C	18	20A-1P				SPARE	
SPARE				20A-1P	19	A----	20	20A-1P				SPARE	
SPARE				20A-1P	21	--B--	22	20A-1P				SPARE	
SPARE				20A-1P	23	---C	24	20A-1P				SPARE	
SPARE				20A-1P	25	A----	26	20A-1P				SPARE	
SPARE				20A-1P	27	--B--	28	20A-1P				SPARE	
SPARE				20A-1P	29	---C	30	20A-1P				SPARE	
SPACE AND PROVISION					31	A----	32					SPACE AND PROVISION	
SPACE AND PROVISION					33	--B--	34					SPACE AND PROVISION	
SPACE AND PROVISION					35	---C	36					SPACE AND PROVISION	
SPACE AND PROVISION					37	A----	38					SPACE AND PROVISION	
SPACE AND PROVISION					39	--B--	40					SPACE AND PROVISION	
SPACE AND PROVISION					41	---C	42					SPACE AND PROVISION	
NOTES:													

Figure 43: Original Panelboard – Classroom

New Panelboard – Classroom

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W	PANEL TAG: 5HA	MIN. C/B AIC: 25 K
SIZE/TYPE BUS: 200A	PANEL LOCATION: Room 513A - Electrical	OPTIONS: PROVIDE FEED THROUGH LUGS
SIZE/TYPE MAIN: 200A/3P C/B	PANEL MOUNTING: SURFACE	FOR PANELBOARD 4HA

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
LIGHTING	Room 514	2430	20A/1P	1	*			2	20A/1P	4008	-	VAV'S
LIGHTING	Room 515	2750	20A/1P	3		*		4	20A/1P	2616	-	VAV'S
LIGHTING	Room 512	1650	20A/1P	5			*	6	20A/1P	2000	Corridor	CORRIDOR LIGHT
LIGHTING	Room 509	2462	20A/1P	7	*			8	20A/1P	2000	Corridor	CORRIDOR LIGHTS
LIGHTING	Room 508	1884	20A/1P	9		*		10	20A/1P	0	-	SPARE
LIGHTING	Room 504/511	2288	20A/1P	11			*	12	20A/1P	0	-	SPARE
LIGHTING	Room 505	1976	20A/1P	13	*			14	20A/1P	0	-	SPARE
LIGHTING	Lobby (5th Floor	2336	20A/1P	15		*		16	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	17			*	18	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	19	*			20	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	21		*		22	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	23			*	24	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	25	*			26	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	27		*		28	20A/1P	0	-	SPARE
SPARE	-	0	20A/1P	29			*	30	20A/1P	0	-	SPARE
SPACE & PROV.	-	0		31	*			32		0	-	SPACE & PROV.
SPACE & PROV.	-	0		33		*		34		0	-	SPACE & PROV.
SPACE & PROV.	-	0		35			*	36		0	-	SPACE & PROV.
SPACE & PROV.	-	0		37	*			38		0	-	SPACE & PROV.
SPACE & PROV.	-	0		39		*		40		0	-	SPACE & PROV.
SPACE & PROV.	-	0		41			*	42		0	-	SPACE & PROV.

CONNECTED LOAD (KW) - A	12.88	TOTAL DESIGN LOAD (KW)	33.84
CONNECTED LOAD (KW) - B	9.59	POWER FACTOR	0.95
CONNECTED LOAD (KW) - C	5.94	TOTAL DESIGN LOAD (AMPS)	43

Figure 44: New Panelboard – Classroom

Feeder Size – Classroom

Feeder Size – Panelboard 5HA	
Calculated Design Load	43.0 A
Feeder Protection Size	45 A
Sets	1
Wire Size	
Phase	#8 AWG
Neutral	#8 AWG
Ground	#10 AWG
Wire Area	
Each Phase	0.0366”
All Phase	0.1098”
Neutral	0.0366”
Ground	0.0211”
Total Area	0.1675”
Conduit Size	¾ ”
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾” conduit 100% Neutral

Table 27: Feeder Size - Classroom

Branch Circuit Redesign – Conclusion

Throughout the redesign of the branch circuits, all of the panelboards either stayed the same size or were smaller. I eliminated panelboard DP2 from the auditorium because the fixtures that were used in the auditorium were only found on 208/120 volt panelboards. The 2005 National Electric Code and the ASHRAE 90.1 Standards were used throughout the lighting and electrical branch circuit redesign. Please see attached CD for spreadsheets of all panelboards mentioned above.

Central Transformer vs. Distributed Transformers

Introduction

The DH Hamilton Building is serviced from the Philadelphia Electric Company (PECO). The 13.2 kV service is fed through a dry-type transformer rated at 480Y/277 volt, 3 phase, and 2500 kVA. After the 2500 kVA transformer, the service is supplied to the main bus system with TVSS located in Substation No. 1. A 4000 draw amp low voltage circuit breaker protects the main bus. The main distribution panels are located on the parking level P2 and fed up through the building into the electrical room of each floor into sub-distribution panels. From the sub-distribution panels, lighting and receptacle loads are distributed to each floor and served by 150 kVA dry-type transformers and 208Y/120V panelboards.

These 150 kVA dry-type transformers are the distributed transformers. The DH Hamilton Building has five distributed transformers throughout the building. The following analysis will provide the original design power riser diagram and single line diagram along with the new design. Note the drawings are only partial drawings. I have also included the original transformer schedule and the new transformer schedule. A cost analysis is done in the construction management breadth.

Central Transformer Size

A conservative power factor of 0.85 and a demand factor of 1.00 were assumed for panelboards 1DPA, 2DPA, 3DPA, 4DPA, and 5DPA. The total calculated design load was calculated using the panelboard schedule spreadsheet. The distribution panelboard for the secondary side of the transformer is 3000A with room for growth with the sixth floor of the DH Hamilton Building. The conduit size and wire size were found on the feeder schedule on the original drawings. The sizes were not changed due to the redesign of the lighting. The wire size was found by using the table for the DH Hamilton Building. This table is the feeder schedule for the building, but it goes by the protection size.

Calculated Design Load	
Panelboard 1DPA	570.6 A
Panelboard 2DPA	495.1 A
Panelboard 3DPA	418.6 A
Panelboard 4DPA	426.1 A
Panelboard 5DPA	516.4 A
Total Calculated Design Load	2426.8 A

Table 28: Calculated Design Load

Central Transformer Size	
Calculated Design Load	2426.8 A
Feeder Protection Size	2500 A
Wire Size (From DH Hamilton Feeder Schedule)	(5) 4" Conduit each with (3) 500 kCmil & (1) #4/0 Ground
Transformer	
kVA	874.29 kVA
Size	1000 kVA
Secondary Protection	2500 A
Primary Protection	1600 A
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral Dry type transformers with primary and secondary feeders exceeding 25 feet

Table 29: Central Transformer Size

Original Electrical Single-Line Diagram – Partial

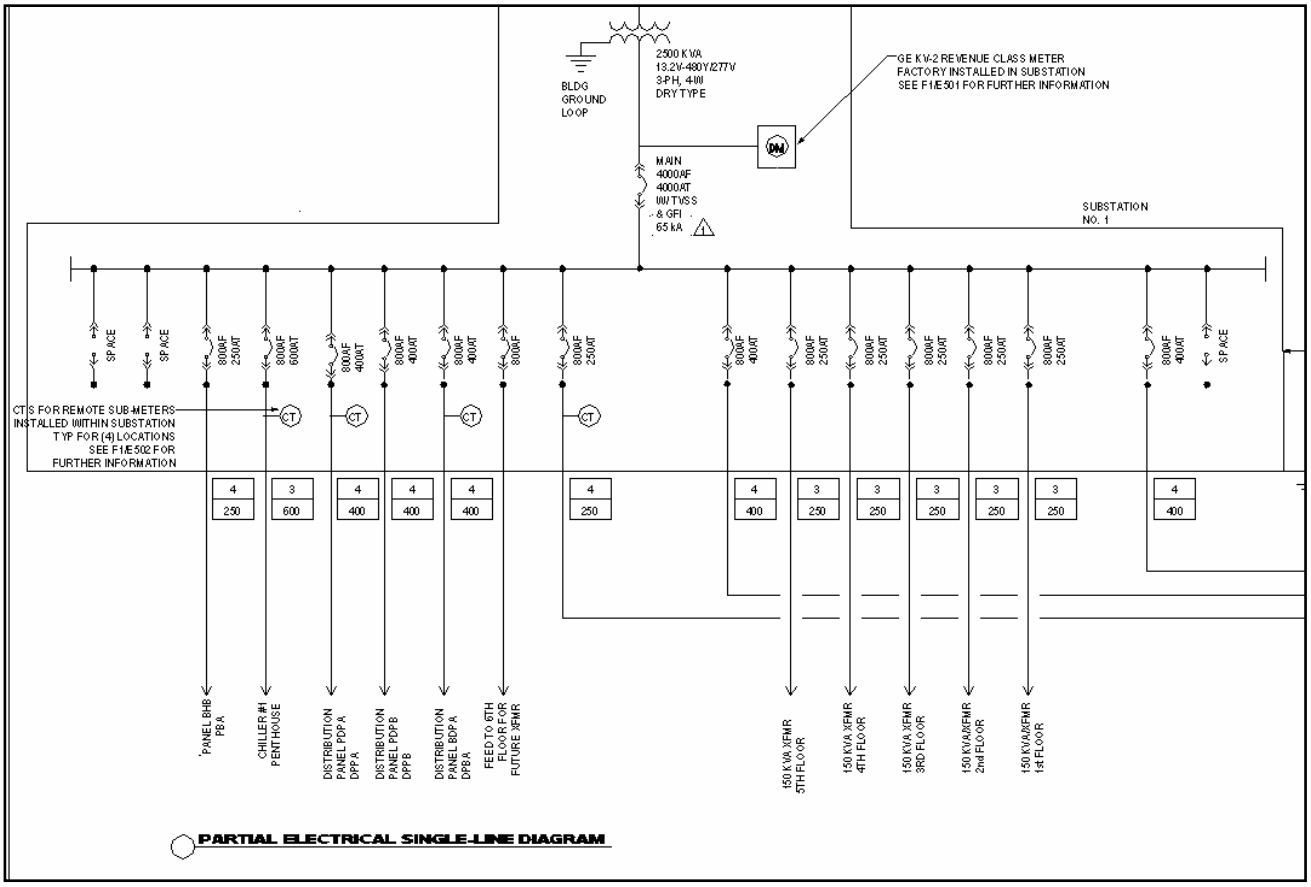

Figure 45: Original Electrical Single-Line Diagram - Partial

New Electrical Single-Line Diagram - Partial

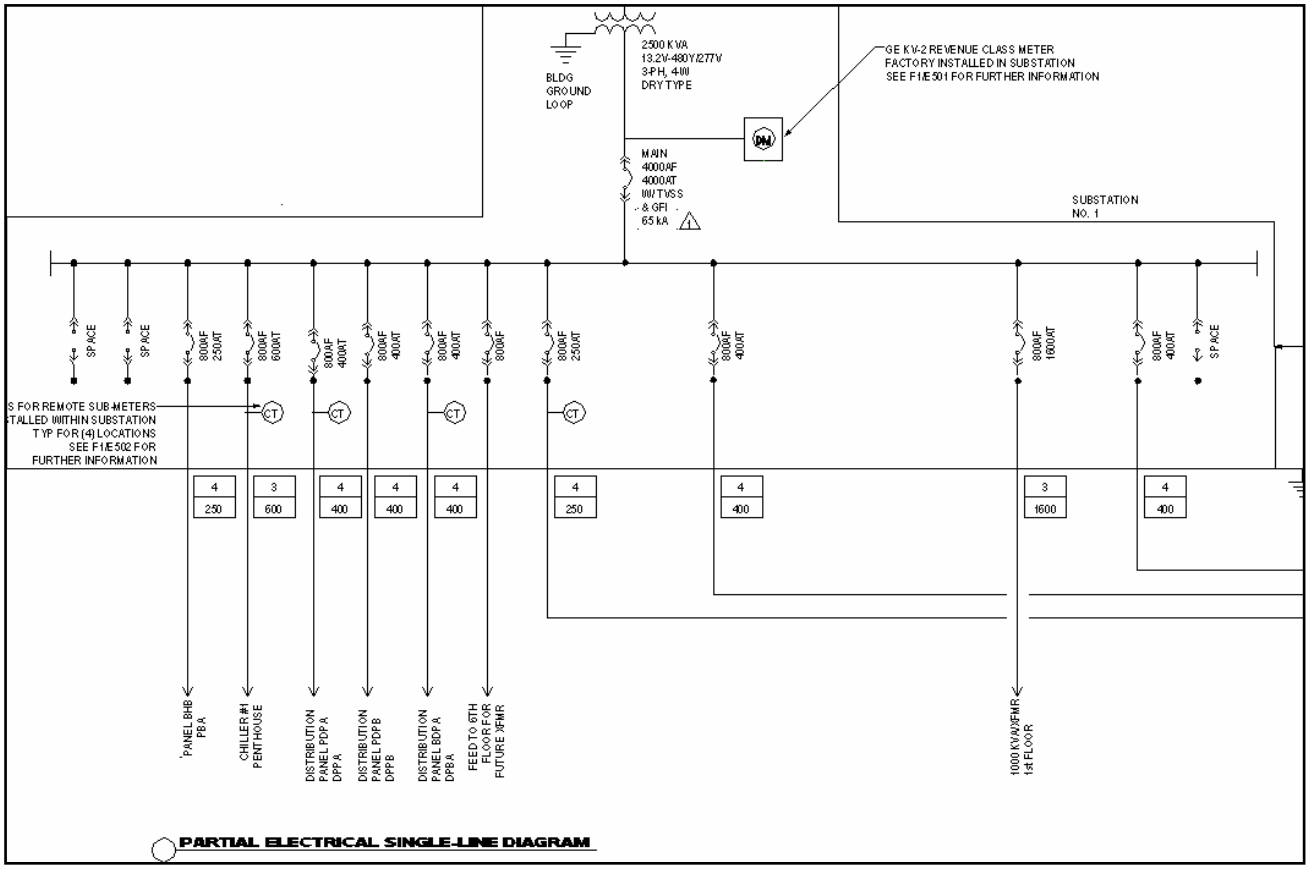

Figure 46: New Electrical Single-Line Diagram - Partial

Original Electrical Riser Diagram – Partial

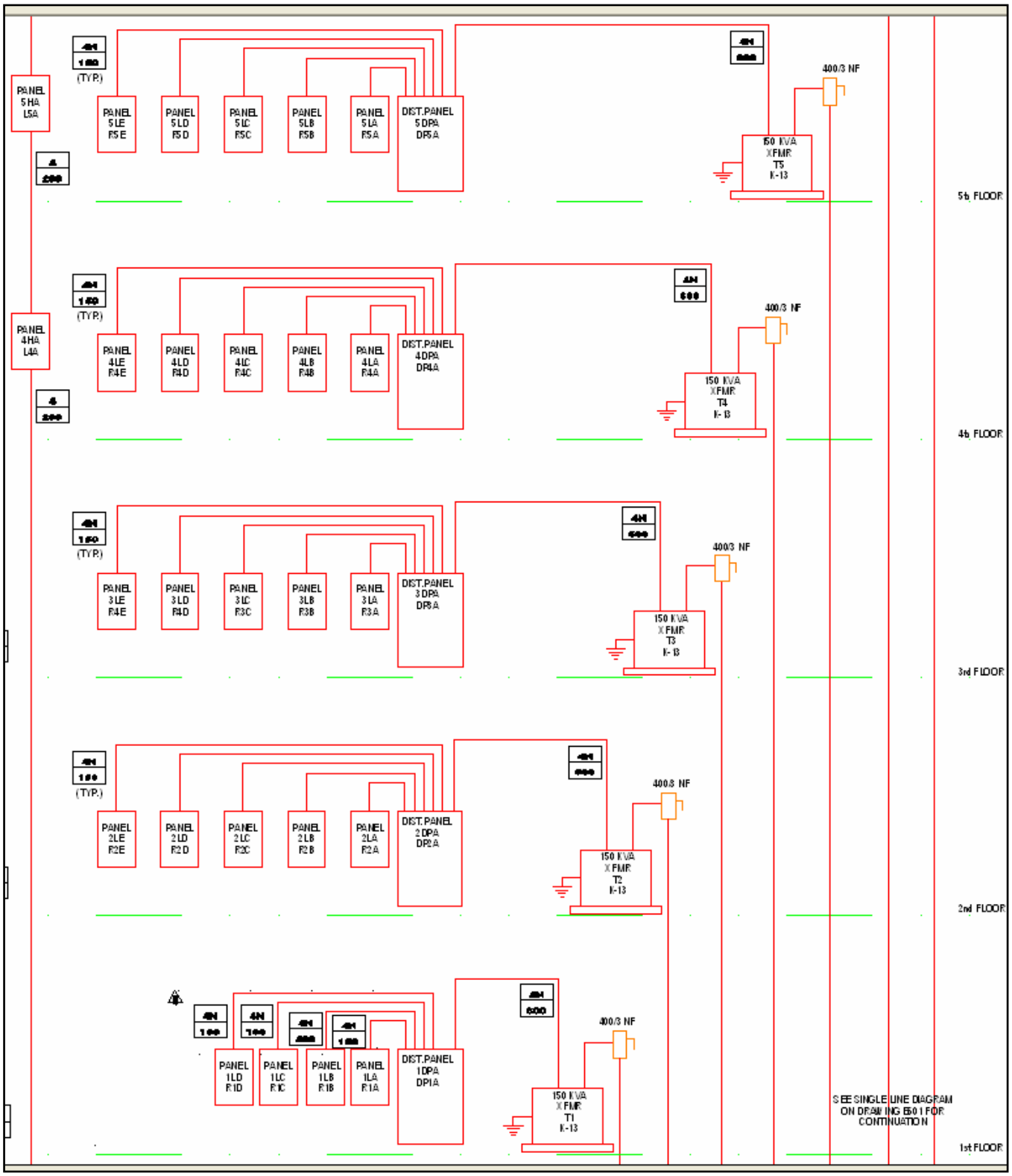

Figure 47: Original Electrical Riser Diagram - Partial

New Electrical Riser Diagram – Partial

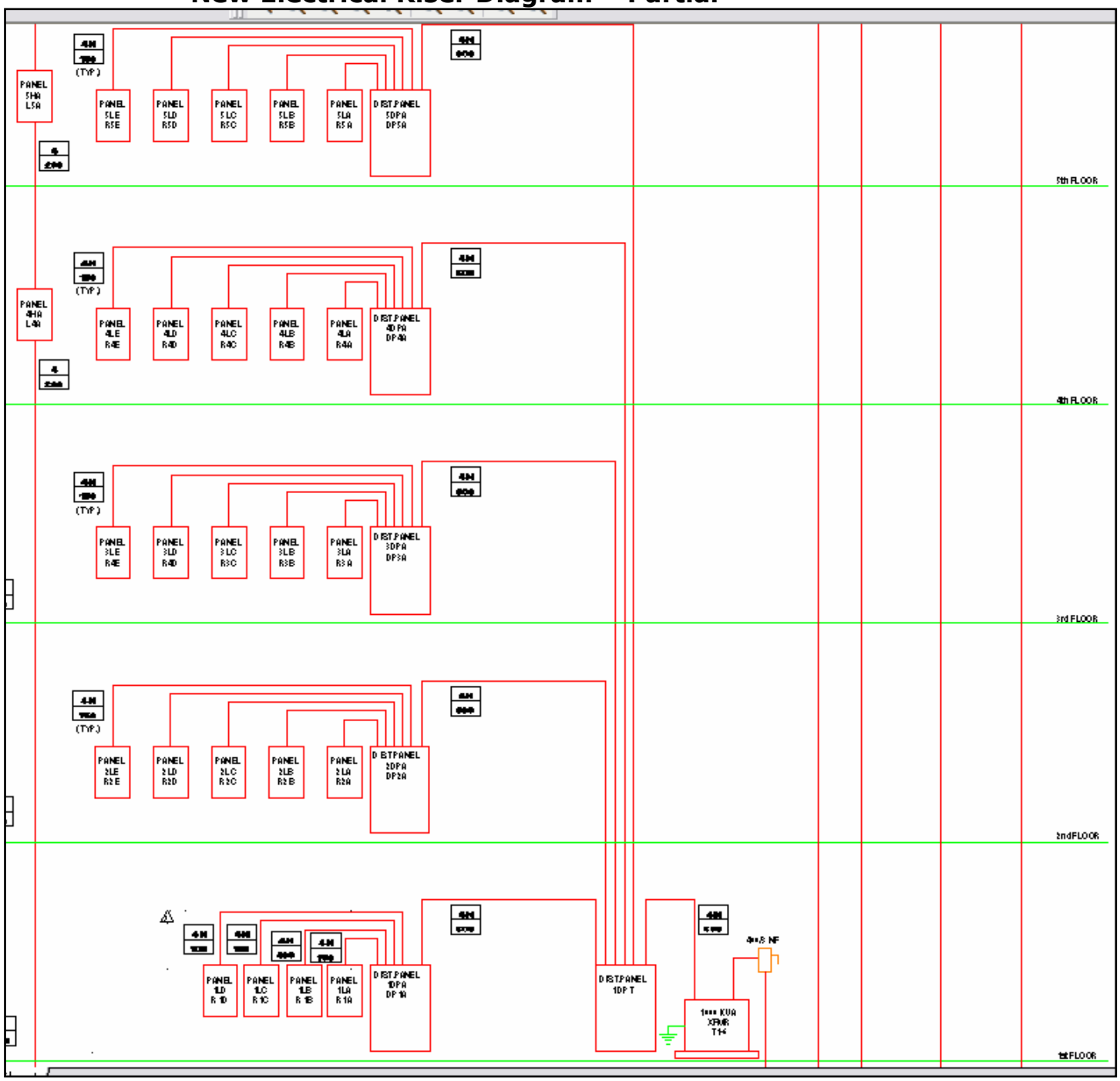

Figure 48: New Electrical Riser Diagram - Partial

Original Transformer Schedule

TRANSFORMER SCHEDULE								
Tag	**Primary Voltage**	**Secondary Voltage**	**Size (kVA)**	**Type**	**Temp. Rise**	**Taps**	**Mounting**	**Remarks**
MAIN	13,200V,3PH,3W	480Y/277V,3PH,4W	2500	DRY TYPE	115°C	N/A	PAD MOUNTED TO FLOOR	N/A
TBA	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
T1	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**150**	**DRY TYPE**	**150°C**	**(4) 2.5%**	**PAD MOUNTED TO FLOOR**	**K-13 RATED**
T2	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**150**	**DRY TYPE**	**150°C**	**(4) 2.5%**	**PAD MOUNTED TO FLOOR**	**K-13 RATED**
T3	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**150**	**DRY TYPE**	**150°C**	**(4) 2.5%**	**PAD MOUNTED TO FLOOR**	**K-13 RATED**
T4	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**150**	**DRY TYPE**	**150°C**	**(4) 2.5%**	**PAD MOUNTED TO FLOOR**	**K-13 RATED**
T5	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**150**	**DRY TYPE**	**150°C**	**(4) 2.5%**	**PAD MOUNTED TO FLOOR**	**K-13 RATED**
T6	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
TP	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
LTBA	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
STBA	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	K-13 RATED
STBB	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
TL1A	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
ST4	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
LPA	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
STPA	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A

NOTES:

1. REFER TO SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
2. TRANSFORMERS 45 KVA AND SMALLER MAY BE FLOOR, WALL, OR TRAPEZE MOUNT AT THE OPTION OF THE CONTRACTOR.

KEY: A/N = AS NOTED

Table 30: Original Transformer Schedule

New Transformer Schedule

TRANSFORMER SCHEDULE

Tag	Primary Voltage	Secondary Voltage	Size (kVA)	Type	Temp. Rise	Taps	Mounting	Remarks
MAIN	13,200V,3PH,3W	480Y/277V,3PH,4W	2500	DRY TYPE	115°C	N/A	PAD MOUNTED TO FLOOR	N/A
TBA	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
T1-61	**480V,3PH,3W**	**208Y/120V,3PH,4W**	**1000**	**DRY TYPE**	**150°C**	**(1) - 3.5%**	**PAD MOUNTED TO FLOOR**	**N/A**
T6	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	() 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
TP	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
LTBA	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
STBA	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	K-13 RATED
STBB	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
TL1A	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
ST4	480V,3PH,3W	208Y/120V,3PH,4W	45	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
LPA	480V,3PH,3W	208Y/120V,3PH,4W	15	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A
STPA	480V,3PH,3W	208Y/120V,3PH,4W	30	DRY TYPE	150°C	(4) 2.5%	FLOOR, WALL, OR TRAPEZE MOUNT	N/A

NOTES:

1. REFER TO SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
2. TRANSFORMERS 45 KVA AND SMALLER MAY BE FLOOR, WALL, OR TRAPEZE MOUNT AT THE OPTION OF THE CONTRACTOR.

KEY: A/N = AS NOTED

Table 31: New Transformer Schedule

Cost Analysis

The cost analysis is part of the construction management breadth; however, it is included in the tables below. The cost analysis is based on THWN copper wire rated at 75°C, IMC conduit, a maximum of 500 kCmil Wire, and a minimum of ¾" conduit. As you can see by the tables below, the cost of the distributed transformer system is $215,987, while the central transformer system is $240,107.

Distributed Transformer Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Transformers				
150 kVA D-Type, K-13 Rated	5.0	EA	16900.00	84,500.00
Copper Feeders (THWN)				
#4 AWG, Stranded	10.3	CLF	229.00	2,347.25
Size 1/0, Stranded	5.5	CLF	450.00	2,466.00
250 kCmil, Stranded	30.8	CLF	925.00	28,443.75
500 kCmil, Stranded	27.4	CLF	1625.00	44,525.00
Conduit (IMC)				
2-1/2"	1025.0	LF	27.00	27,675.00
4"	548.0	LF	47.50	26,030.00
TOTAL				**$215,987.00**
Remarks	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Miniumum 3/4" Conduit 100% Neutral			

Table 32: Distributed Transformer Estimate

Central Transformer Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Transformers				
1000 kVA D-Type Transformer	1.0	EA	43200.00	43,200.00
Copper Feeders (THWN)				
#4 AWG, Stranded	0.9	CLF	229.00	201.52
Size 1/0, Stranded	13.4	CLF	450.00	6,021.00
250 kCmil, Stranded	2.6	CLF	925.00	2,442.00
500 kCmil, Stranded	66.9	CLF	1625.00	108,712.50
Distribution Panelboards 4-Wire, 120/208V, 3000 Amp	1.0	EA	15975.00	15,975.00
Conduit (IMC)				
2-1/2"	88.0	LF	27.00	
4"	1338.0	LF	47.50	63,555.00
TOTAL				**$240,107.02**
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Miniumum 3/4" Conduit 100% Neutral			

Table 33: Central Transformer Estimate

Conclusion

Overall, the central transformer system is not recommended due to the overall cost. The central transformer is 109% the cost of the five distributed transformers. The central transformer will save on square footage for the space, but the transformer cost is higher than the five distributed transformers. The recommendation is to keep the original design with the distributed transformers.

Feeders vs. BusDuct

Introduction

The DH Hamilton Building is serviced from the Philadelphia Electric Company (PECO). The main distribution panels are located on the parking level P2 and fed up through the building into the electrical room of each floor into sub-distribution panels with feeders. From the sub-distribution panels, lighting and receptacle loads are distributed to each floor and served by 150 kVA dry-type transformers and 208Y/120V panelboards.

The feeders running from the parking level P2 to the penthouse are going to be replaced by a busduct. The following analysis will provide the original design power riser diagram and single line diagram along with the new design. Note the drawings are only partial drawings. The original full drawings are located on the CPEP website. A cost analysis is done in the construction management breadth.

Calculated Design Load

A conservative power factor of 0.85 and a demand factor of 1.00 were assumed for panelboards 1DPA, 2DPA, 3DPA, 4DPA, and 5DPA. An additional 20% growth was assumed for the future of floor six. Currently, floor six is an empty space and a future load will be placed on the floor. The total calculated design load was calculated using the panelboard schedule spreadsheet. The conduit size and wire size were found on the feeder schedule on the original drawings. The sizes were not changed due to the redesign of the lighting. The wire size was found by using the table for the DH Hamilton Building. This table is the feeder schedule for the building, but it goes by the protection size.

Calculated Design Load	
Panelboard 1DPA	570.6 A
Panelboard 2DPA	495.1 A
Panelboard 3DPA	418.6 A
Panelboard 4DPA	426.1 A
Panelboard 5DPA	516.4 A
Panelboard 6DPA (Future)	485.4 A
Total Calculated Design Load	2912.2 A
Busduct Design Load	600 A

Table 34: Calculated Design Load

Original Electrical Single-Line Diagram - Partial

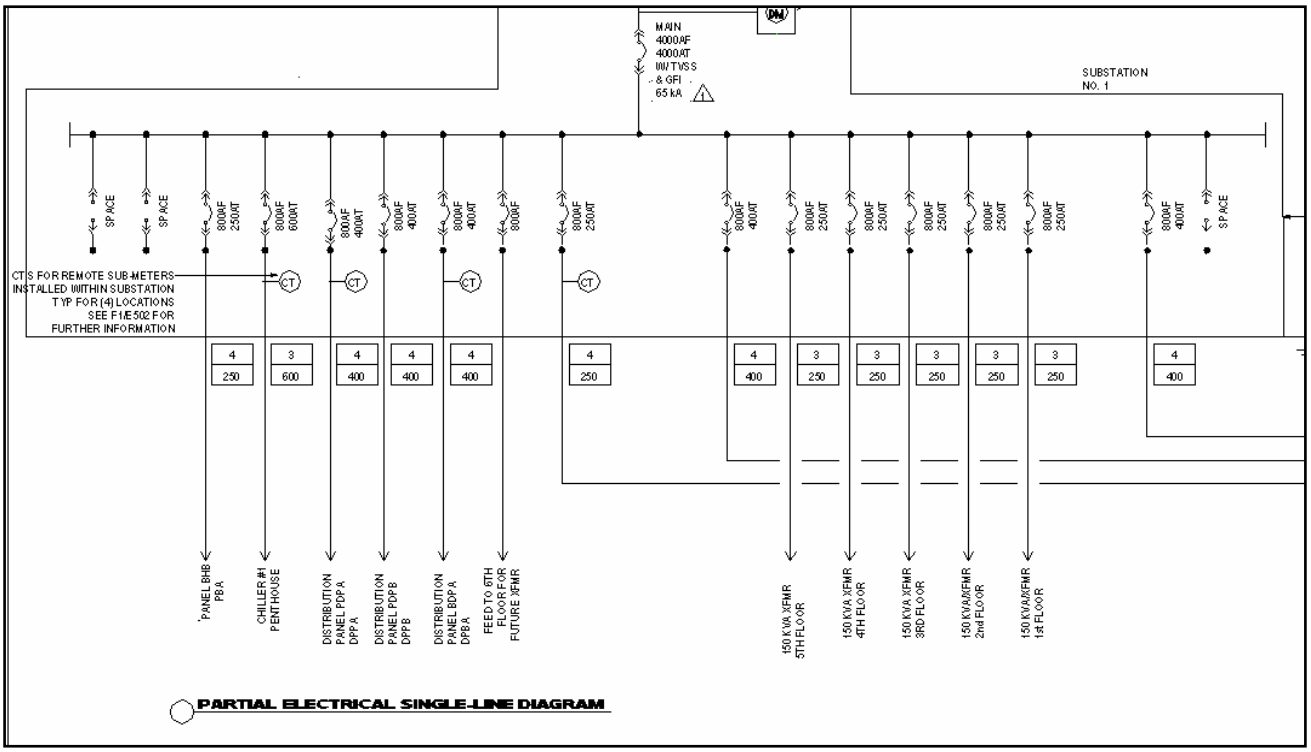

Figure 49: Original Electrical Single-Line Diagram - Partial

New Electrical Single-Line Diagram - Partial

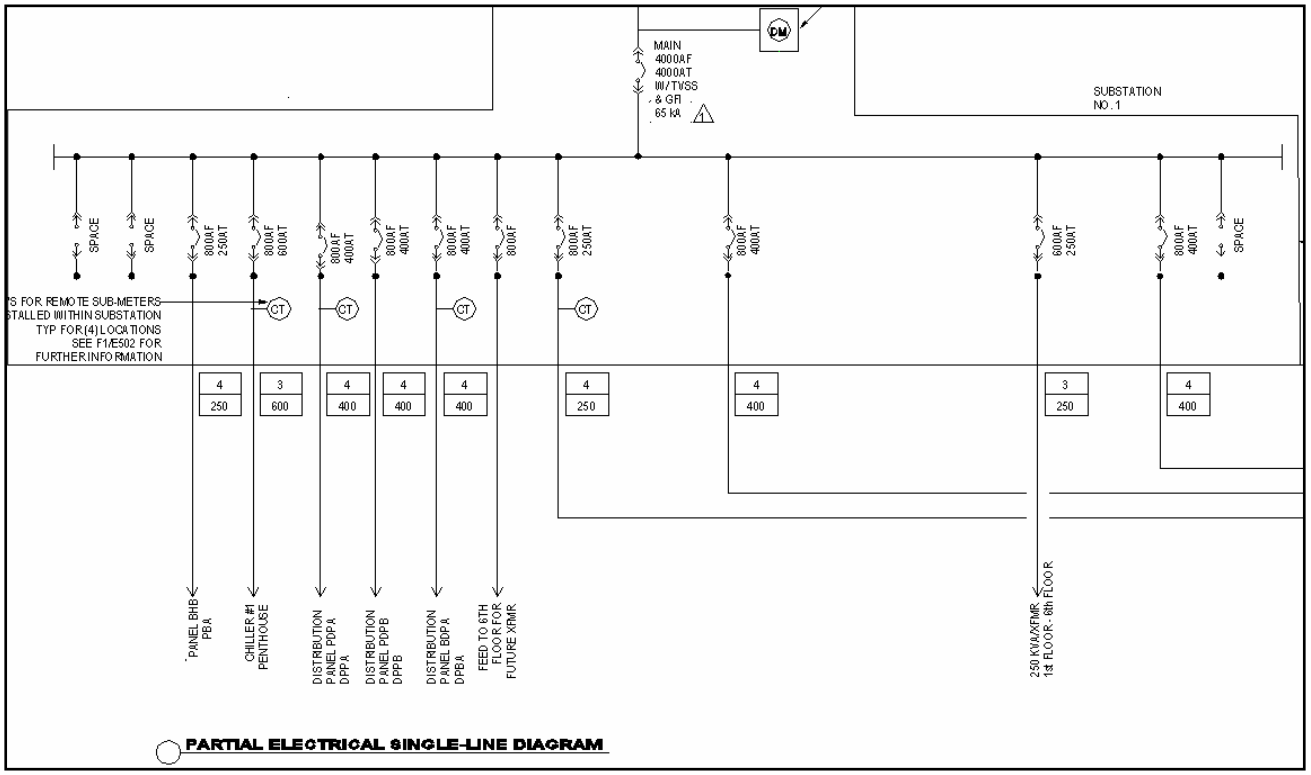

Figure 50: New Electrical Single-Line Diagram - Partial

Original Electrical Riser Diagram – Partial

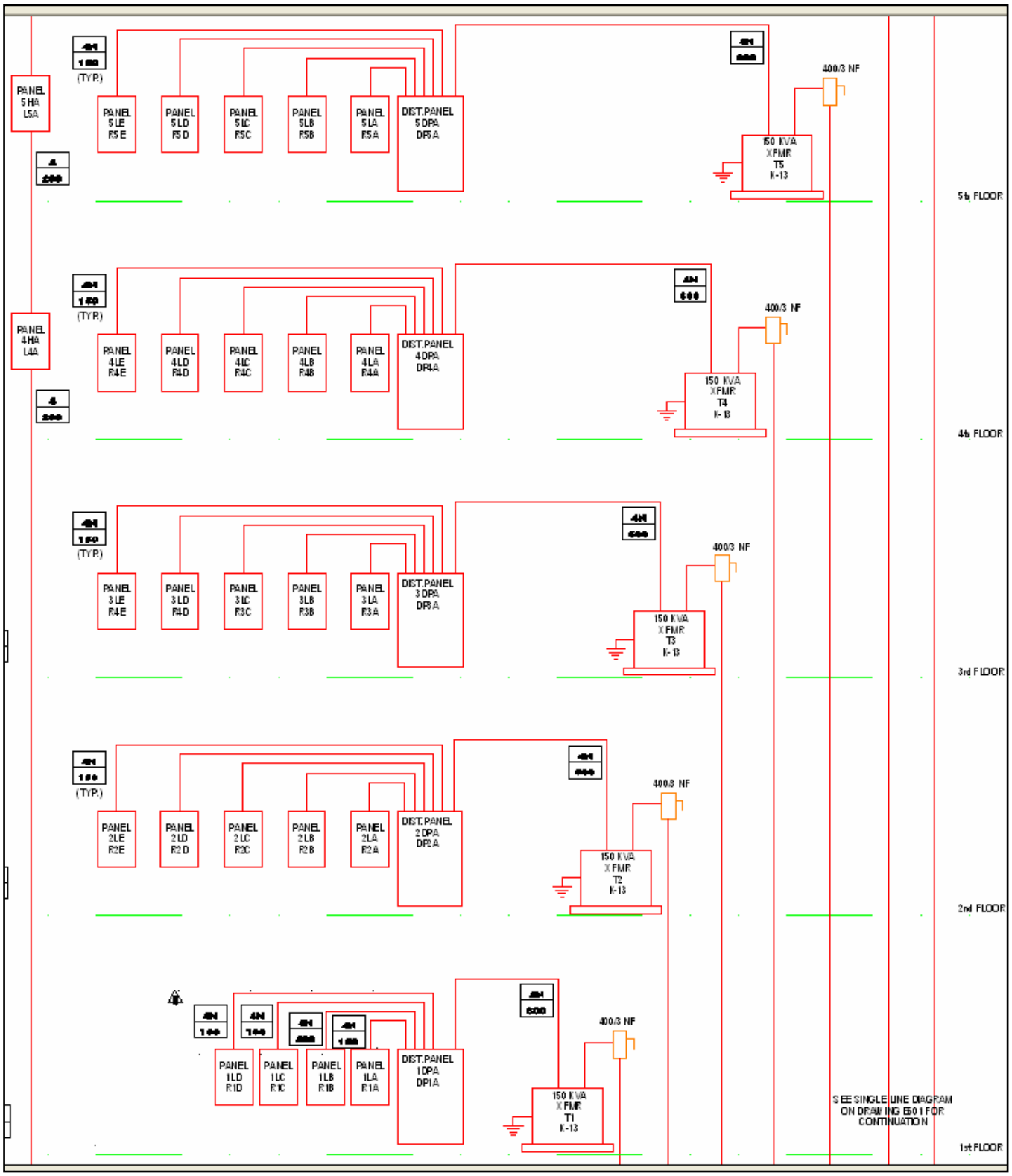

Figure 51: Original Electrical Riser Diagram - Partial

New Electrical Riser Diagram – Partial

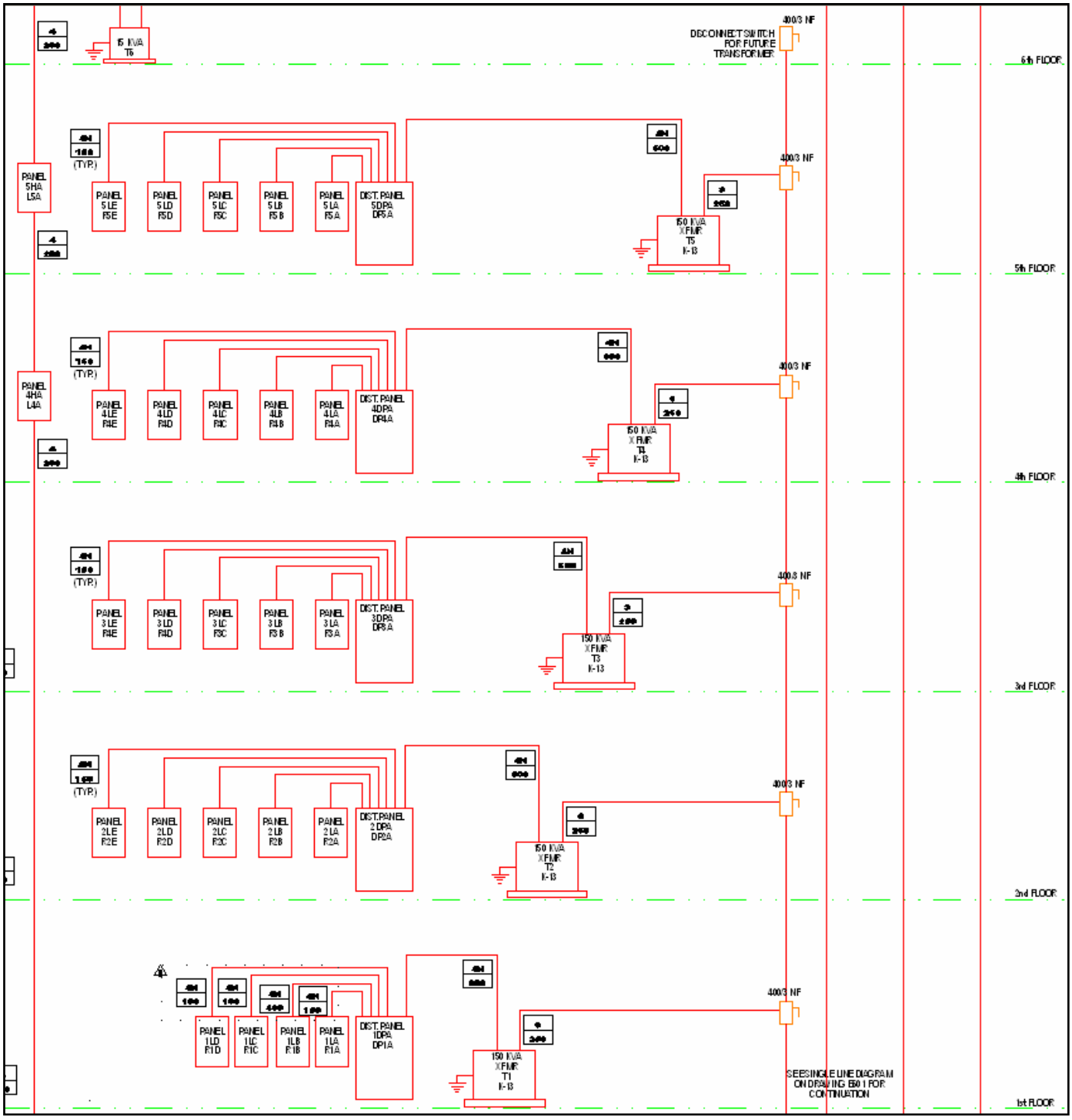

Figure 52: New Electrical Riser Diagram - Partial

Cost Analysis

The cost analysis is part of the construction management breadth; however, it is included in the tables below. The cost analysis is based on THWN copper wire rated at 75°C, IMC conduit, a maximum of 500 kCmil Wire, and a minimum of ¾" conduit. As you can see by the tables below, the cost of the system with only feeders is $59,606, while the cost of the system with the busduct is $55,098.

Feeder Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Copper Feeders (THWN)				
#4 AWG, Stranded	10.5	CLF	229.00	2,393.05
250 kCmil, Stranded	31.4	CLF	925.00	28,998.75
Conduit (IMC)				
2-1/2"	1045.0	LF	27.00	28,215.00
TOTAL				**$59,606.80**
Remarks	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Miniumum 3/4" Conduit 100% Neutral			

Table 35: Feeder Estimate

Busway Estimate				
Item	Quantity	Units	Cost (Inc. O&P)	Total Cost
Indoor/Plug-in Busduct				
Copper Busduct - 600A	220.0	LF	210.00	46,200.00
Feeders				
#4 AWG	1.6	CLF	229.00	357.24
250 kCmil	4.7	CLF	925.00	4,329.00
Conduit (IMC)				
2-1/2"	156.00	LF	27.00	4,212.00
TOTAL				**$55,098.24**
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kCmil Wire Miniumum 3/4" Conduit 100% Neutral			

Table 36: Busway Estimate

Conclusion

Overall, the busduct is recommended due to the overall cost. The busduct is 92% the cost of the individual feeders. The feeder system used 1045’ of (3) 250 kCmil & (1) #4G in 2-1/2” conduit. This equates to $59,606 for the system. The busduct system used 220’ of vertical copper 600 A busduct and 156’ of (3) 250 kCmil & (1) #4G in 2-1/2” conduit. This equates to $55,098 for the system. The recommendation is to switch to the busduct instead of the individual feeders.

Motor Control Center

Introduction

The motor control center design consists of the analysis and design of one major mechanical equipment motor control center and associated feeder. A schedule will be provided along with the calculation tables of design loads for branch conductors, feeders, and protective devices. The DH Hamilton Building motor control center will consist of the three AHU motors, the two AHU return fans, two roof supply fans, two garage exhaust fans, the chiller pump, spare chiller pump, and the cooling tower pump.

Motor Control Center Loads

Tag	Equipment Type	Voltage	Phase	Power	Full Load Amps	Power Factor	Load (kVA)
AHU-1	AHU	460 V	3	75 HP	96 A	0.90	71.83
AHU-2	AHU	460 V	3	75 HP	96 A	0.90	71.83
AHU-3	AHU	460 V	3	75 HP	96 A	0.90	71.83
RF-1	AHU Return Fan	460 V	3	50 HP	65 A	0.90	48.64
RF-2	AHU Return Fan	460 V	3	50 HP	65 A	0.90	48.64
SF-3	Stairwell Pressure Fan	460 V	3	20 HP	27 A	0.90	20.20
SF-4	Stairwell Pressure Fan	460 V	3	20 HP	27 A	0.90	20.20
EF-7	Garage Exhaust Fan	460 V	3	30 HP	40 A	0.90	29.93
EF-8	Garage Exhaust Fan	460 V	3	30 HP	40 A	0.90	29.93
P-1	Chiller Pump	460 V	3	40 HP	52 A	0.90	38.91
P-2	Spare Pump	460 V	3	40 HP	52 A	0.90	38.91
P-3	Cooling Tower Pump	460 V	3	40 HP	52 A	0.90	38.91

Table 37: Motor Control Center Loads

The table above states the motor control center schedule. The loads and the NEMA starter sizes are all shown in the above table. The types of fans are variable frequency drive (VFD) and full voltage, non-reversing (FVNR).

Motor Control Center Schedule

Equipment	Motor Type	Power	NEMA Starter Size	# X Spaces	Type of VFD	FLA	Demand Factor	Total Amps
AHU-1	VFD	75 HP	4	12X	SVX9000	71.83	1.25	89.79
AHU-2	VFD	75 HP	4	12X	SVX9000	71.83		71.83
AHU-3	VFD	75 HP	4	12X	SVX9000	71.83		71.83
RF-1	VFD	50 HP	3	12X	SVX9000	48.64		48.64
RF-2	VFD	50 HP	3	12X	SVX9000	48.64		48.64
SF-3	FVNR	20 HP	2	1X	N/A	20.20		20.20
SF-4	FVNR	20 HP	2	1X	N/A	20.20	1.00	20.20
EF-7	FVNR	30 HP	3	2X	N/A	29.23		29.23
EF-8	FVNR	30 HP	3	2X	N/A	29.23		29.23
P-1	VFD	40 HP	3	7X	SVX9000	38.91		38.91
P-2	VFD	40 HP	3	7X	SVX9000	38.91		38.91
P-3	VFD	40 HP	3	7X	SVX9000	38.91		38.91
Total Design Load								546.32

Table 38: Motor Control Center Schedule

Since the design load is 546 Amps, 600 amp busduct is needed to supply the motor control center. A 600-amp busduct will need 6X number of spaces for a bottom cable entry with four cables per phase.

Therefore, I need a total of 93 X number of spaces. Since there are 12X spaces per section, I will need 8 sections. Since this is a rather large motor control center, a spare section is going to be added, which makes the total to be 9 sections. The final dimensions of the motor control center are 16” deep, 90” high, and 180” long. The penthouse will have enough room to house this huge motor control center.

Motor Control Center Size

Motor Control Center	
Calculated Design Load	546.32 A
Feeder Protection Size	600 A
Wire	(2) sets of 250 kCmil & (1) #1 Ground
Conduit	3 ½"
Secondary Protection	600 A
Primary Protection	700 A
Remarks:	Based on Copper Wire, 75°C, THWN insulation IMC Conduit Maximum 500kcmil wire Minimum ¾" conduit 100% Neutral Dry type transformers with primary and secondary feeders exceeding 25 feet

Table 39: Motor Control Center Size

Motor Control Center Layout

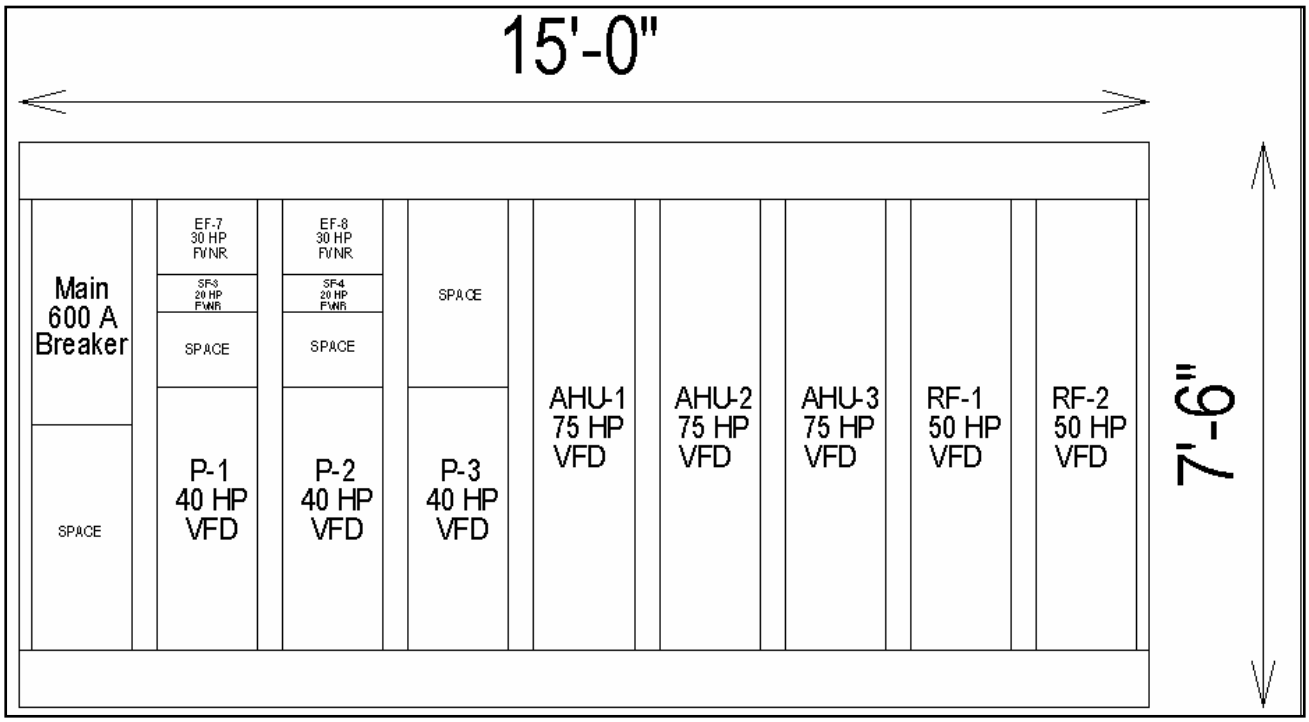

Figure 53: Motor Control Center Layout

Conclusion

The motor control center will provide an adequate space saver in the mechanical room of the DH Hamilton Building. All motors over 20 HP were put into the motor control center. This should provide the motor starters with the correct amperage to start and also the variable frequency drive system for the air handling unit motors, the return fan motors, and the pumps. The motor control center would be an addition to the DH Hamilton Building that would be recommended.

Short Circuit Analysis

Introduction

The short circuit analysis will conduct a brief protective device study that addresses a single-path through the distribution system.

Protective Device Coordination

The protective device coordination was performed on the 100 amp circuit breaker of panelboard 1LD, the 600 amp main distribution panelboard 1DPA, and the 800 amp circuit breaker off of the main buss. The circuit breaker time/current curves are on the pages following the conclusion.

Short Circuit Calculations

The short circuit calculations cannot be completed because the utility information is unattainable from the Thomas Jefferson University.

Conclusion

All of the systems were coordinated by overlaying the devices upstream of the device before itself. Therefore, the single-path through the distribution system is coordinated.

Panelboard 1LD - 100 Amp Trip Curve

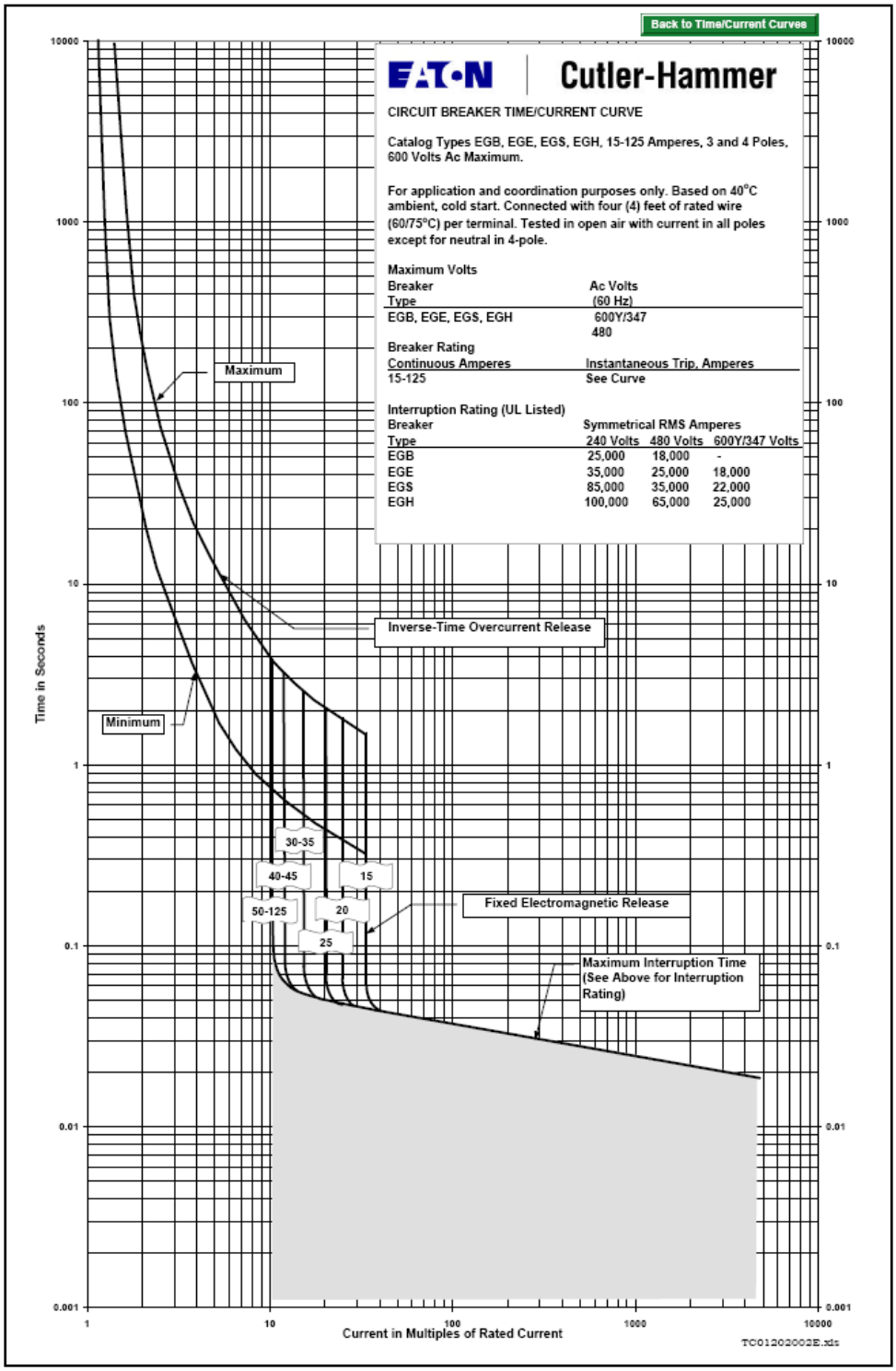

Figure 54: 100 Amp Trip Curve

Panelboard 1DPA – 400 Amp Trip Curve

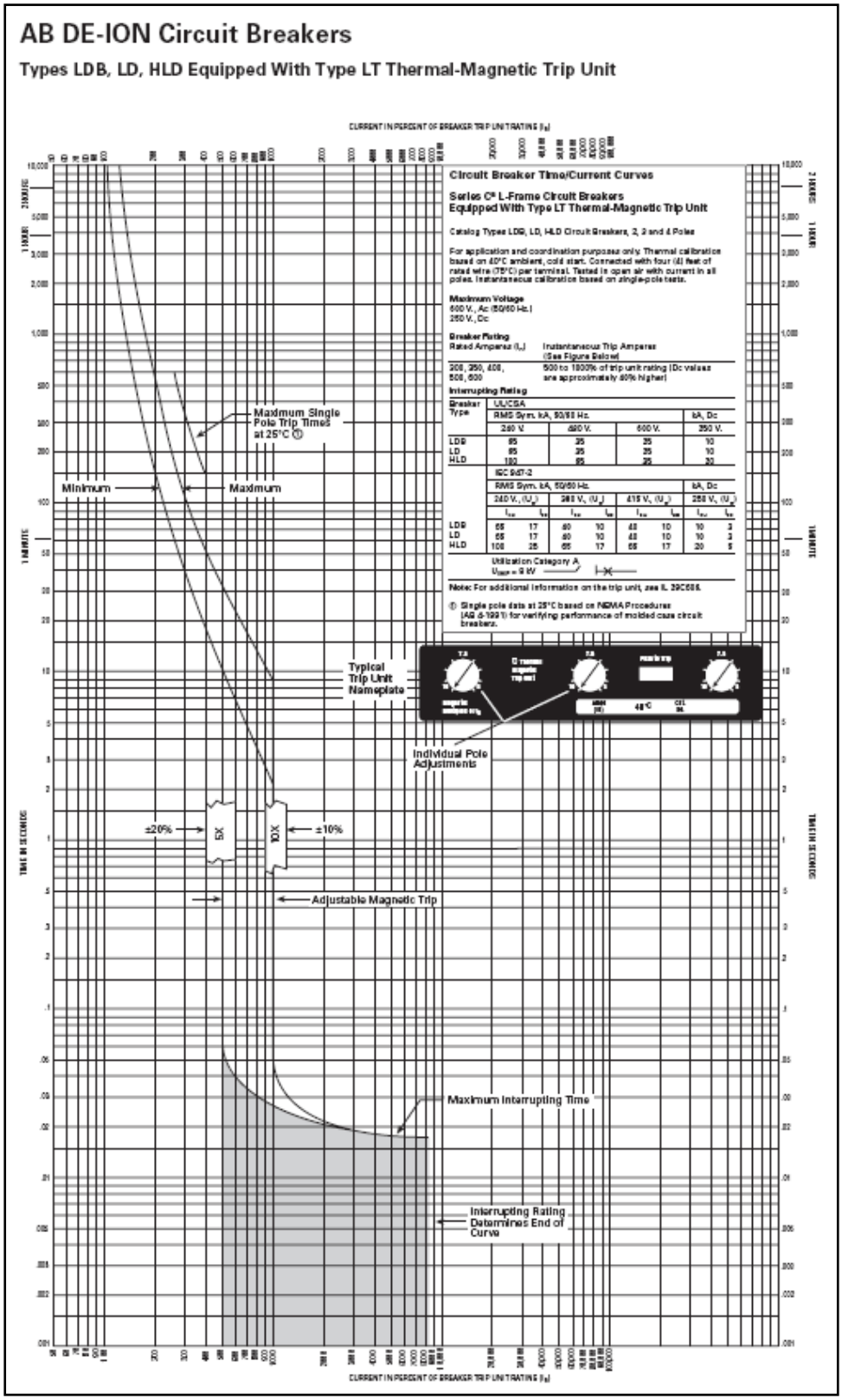

Figure 55: 400 Amp Trip Curve

Feeder - 800 Amp Trip Curve

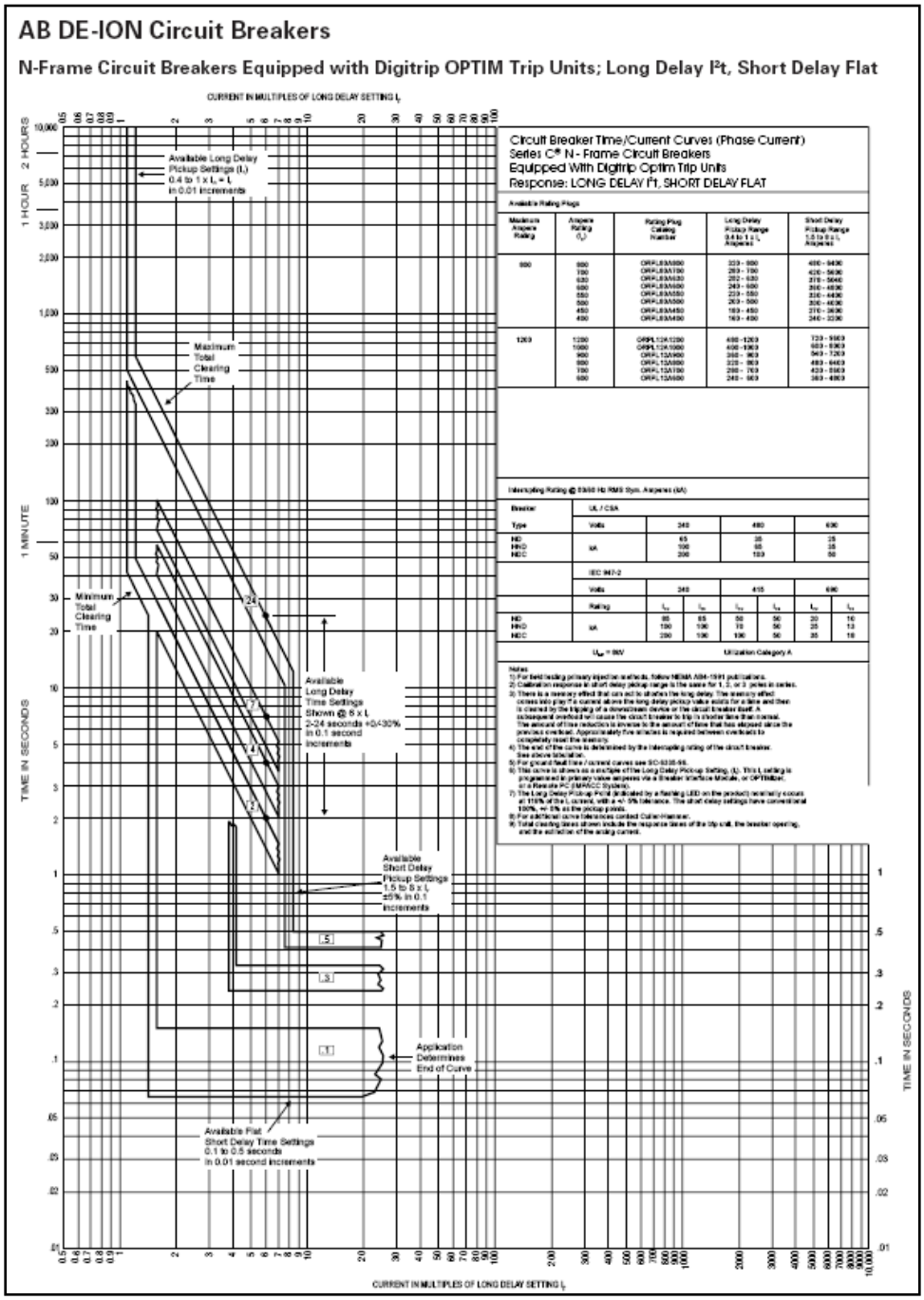

Figure 56: 800 Amp Trip Curve