3.0 INTRODUCTION TO ELECTRICAL DEPTH

In conjunction with the lighting system redesign, feeder and branch circuits were designed or modified as necessary to provide proper power to the new lighting system. The redesigned spaces are now supplied by 277 volt A/C power rather than 120 volts. A 277 volt system was selected because there is already a 277 volt transformer in the building's basement that is capable of handling the new loads. The new 277 volt system is most advantageous in the large gallery area, which can now utilize longer track runs.

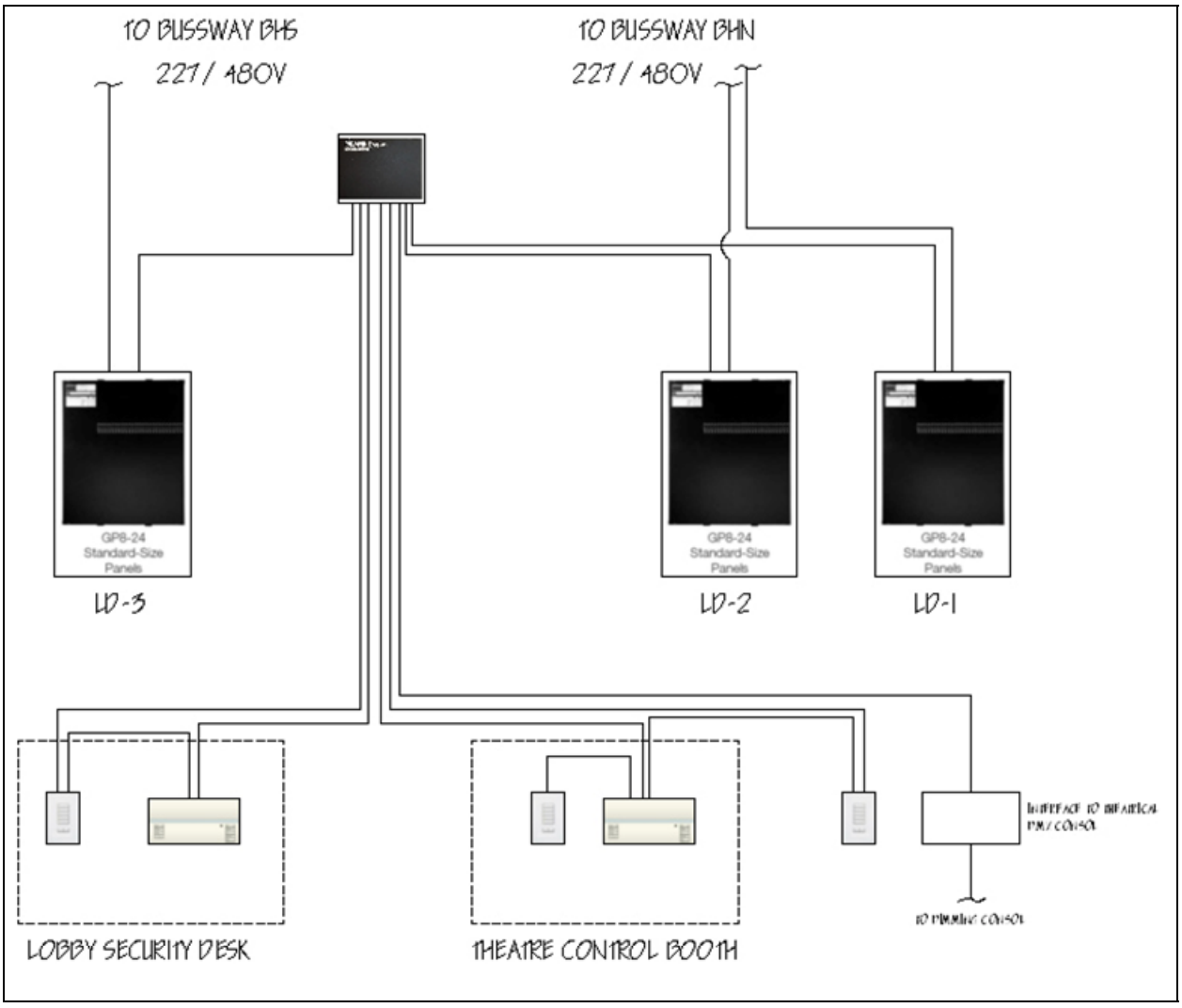
In addition to converting the redesigned spaces to a 277 volt system, a new centralized dimming and control system has been specified to simplify building operation. Following this section is a discussion on the potential savings that may be realized if new and existing feeders were to be specified with cheaper aluminum wiring rather than the existing copper conduit. Finally, a coordination study from panelboard to power feed is analyzed to determine if circuit breakers will trip properly.

3.1 LIGHTING CONTROL SYSTEMS

The redesigned electrical system includes a simple, centralized lighting control interface that makes managing the redesigned lighting spaces intuitive. The lobby security desk serves as a centralized location from which all dimmed, switched, and timeclocked lighting systems can be operated. Lutron See-Touch preprogrammed scenes allow the users to press simple buttons to control the lighting systems.

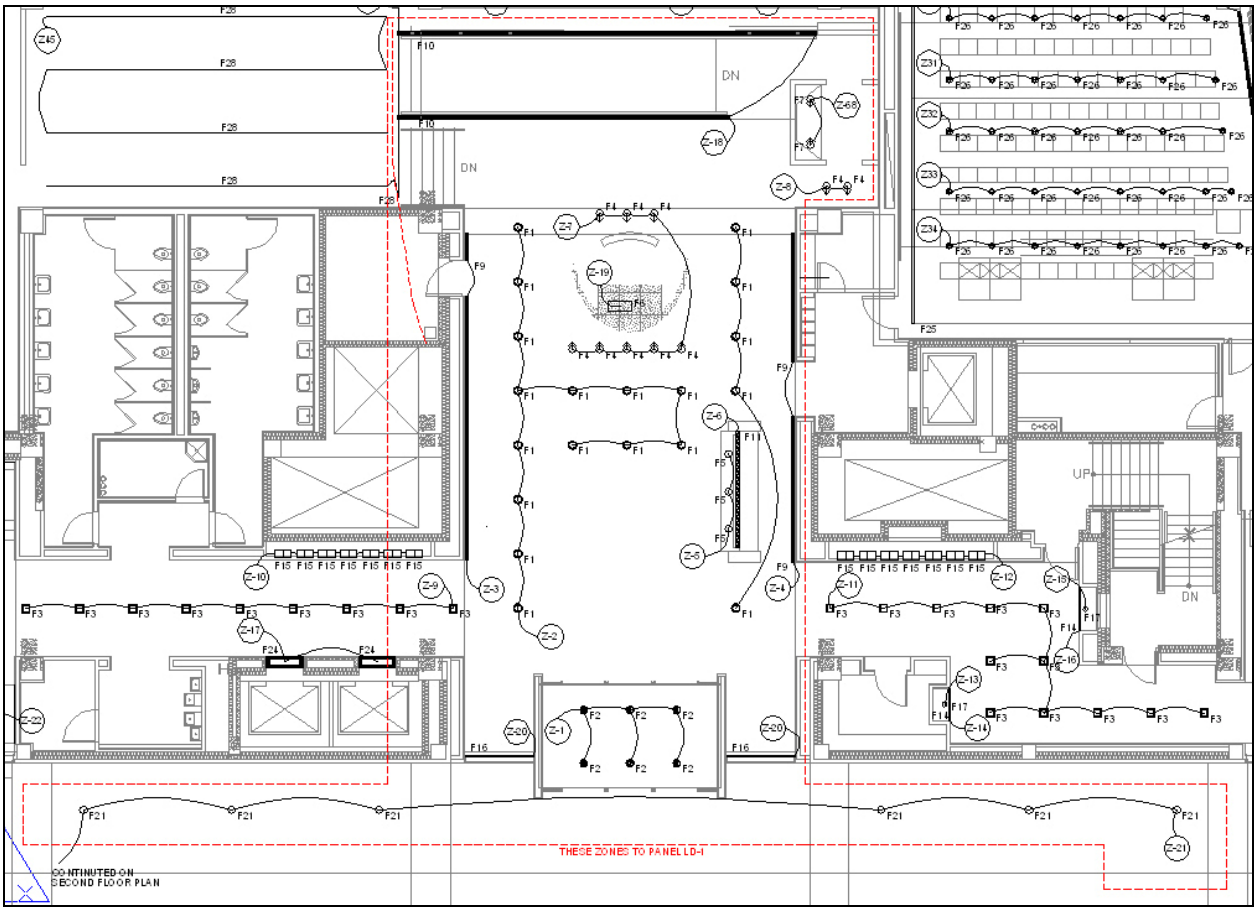
All lighting controls on the Lutron system are connected to an anatomical timeclock with present scenes for 7:00, 12:00, and 18:00 solar time. Dimming adjustments can be made to allow preprogrammed See-Touch buttons to call different light levels depending on the time of the day. For example, pressing "Lobby High" may bring the lights to a different dimming level at 2:00 PM than if the same button were pressed at 10:00 PM. This system has also been incorporated into the Gutenberg Bible display and First Photograph area to allow light levels to be reduced during daylight hours.

Dimming Controls Line Diagram

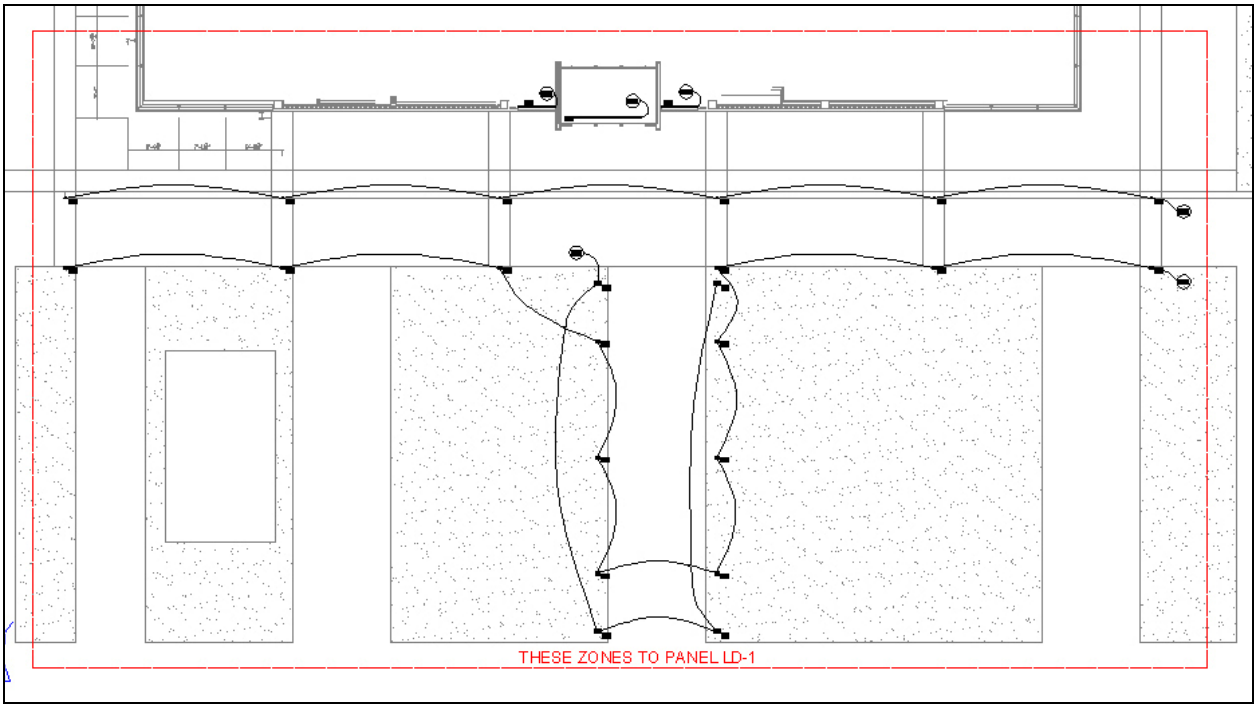


Lighting controls have also been incorporated into the theatre spaces. To allow more space for control channels on the theatrical panel, lighting loads previously connected to the theatre dimming rack have been relocated to Lutron Grafik Eye panel LD-2. An interface device has been specified that will allow the DMX consol to patch into the Lutron system and control the house lights. This will allow the theatrical designer to have more dimming capacity for performances without losing the ability to include house lighting in their performance cues.

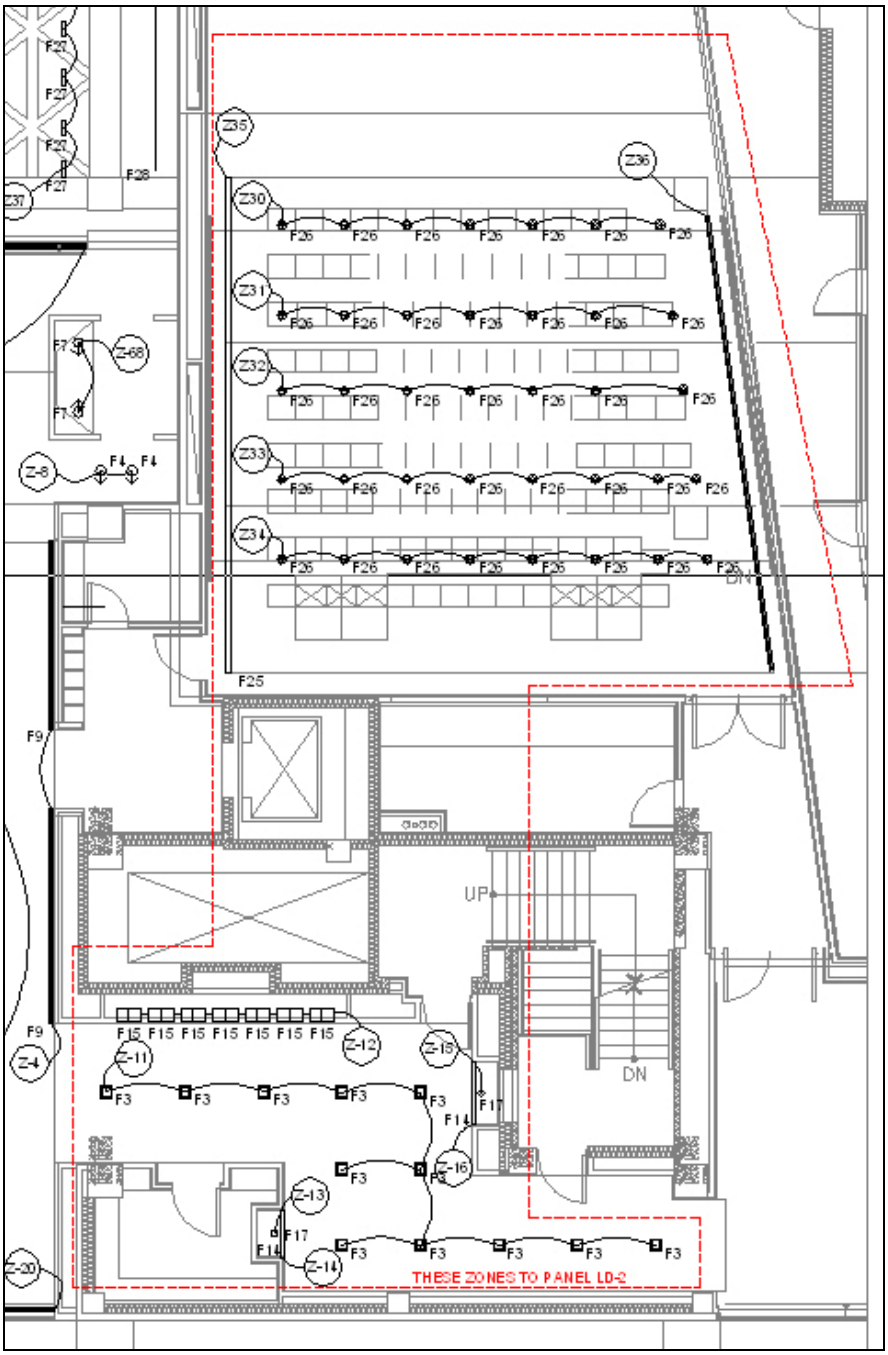
Control Zones for Panel LD-1, First Floor



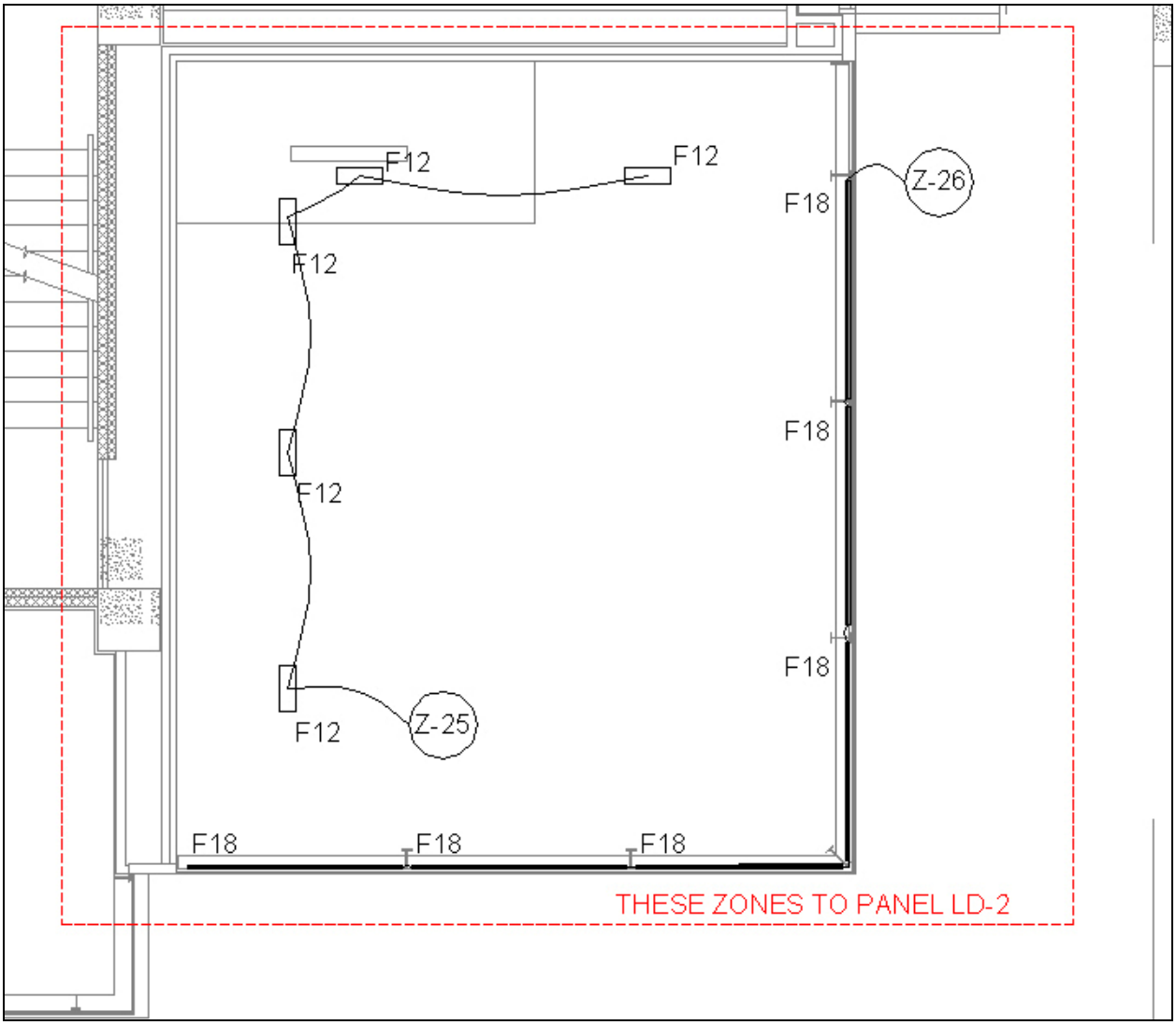
Control Zones for Panel LD-1, Exterior Lighting



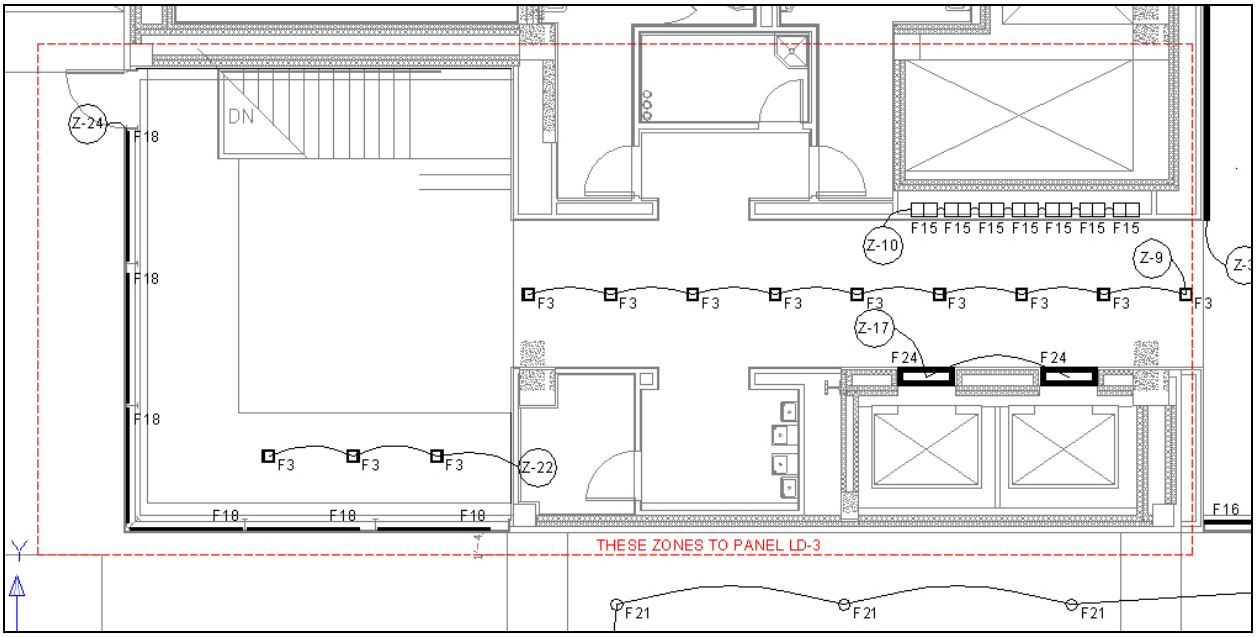
Control Zones for Panel LT-2, First Floor



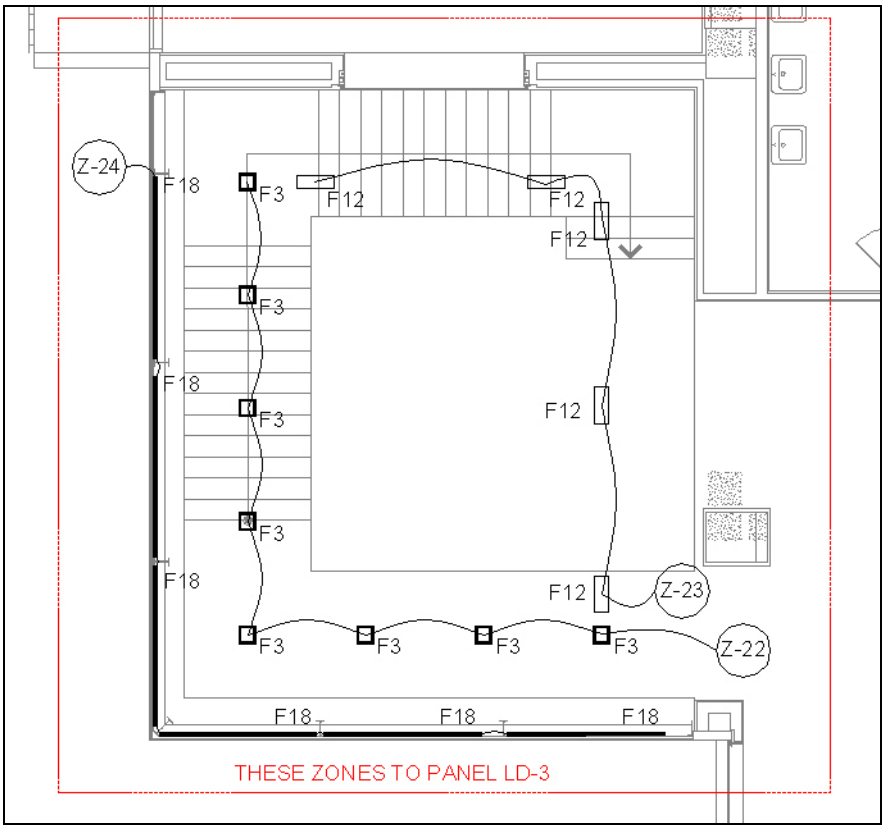
Control Zones for Panel LD-2, Atrium RCP



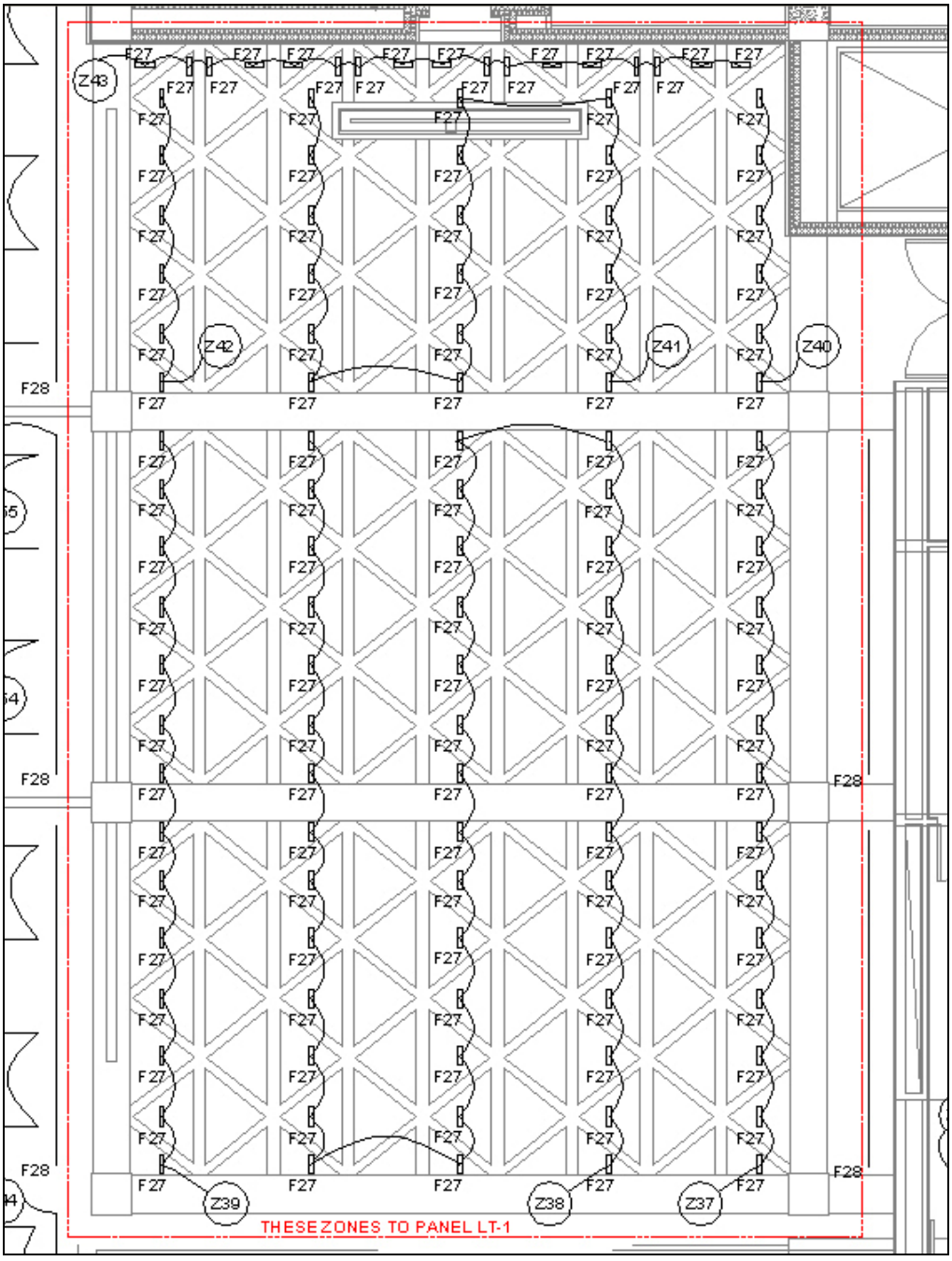
Control Zones for Panel LD-3, First Floor



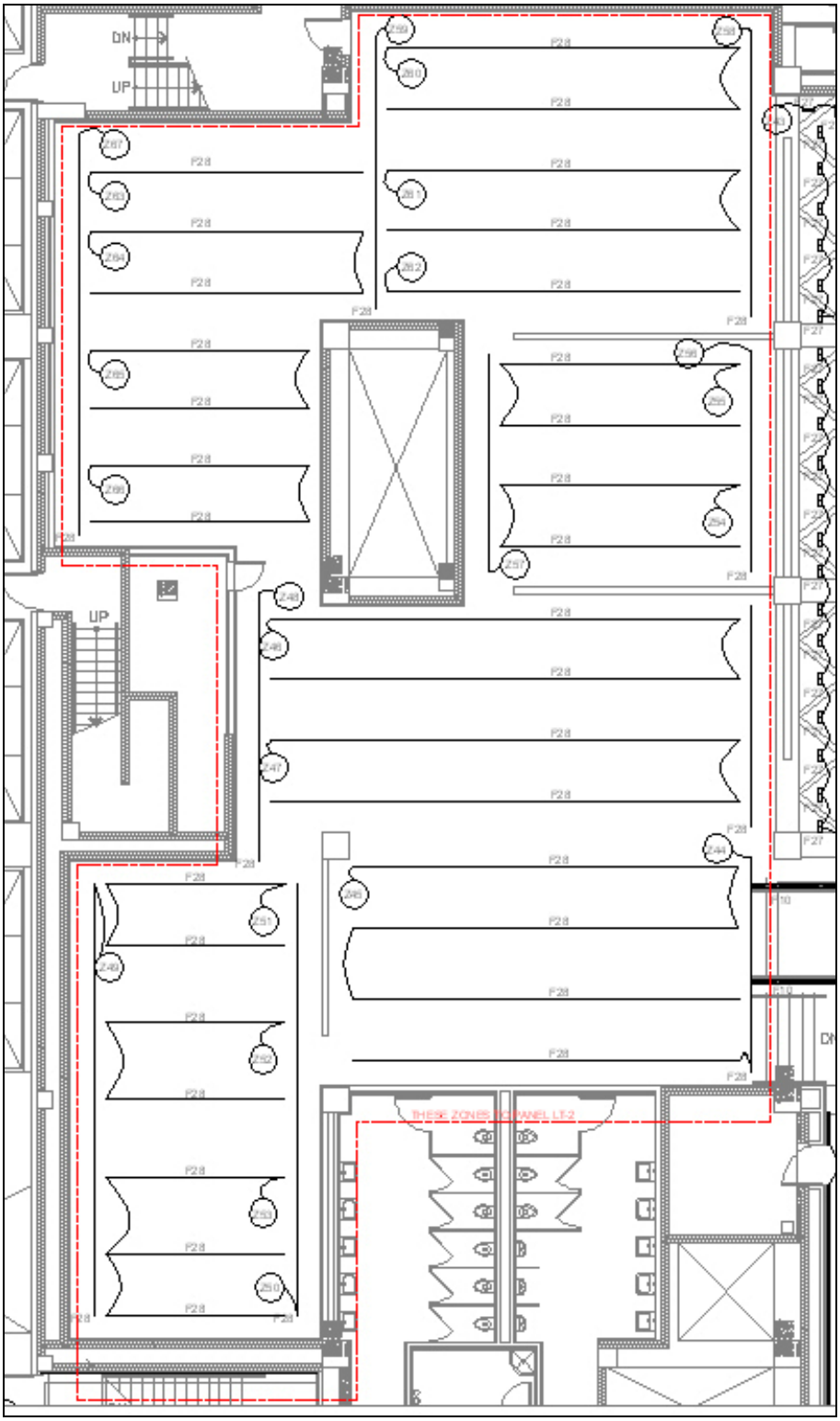
Control Zones for Panel LD-3, Atrium RCP



Control Zones for Panel LT-1, Prothro Gallery



Control Zones for Panel LT-2, Prothro Gallery



3.2 PANELBOARD SCHEDULES

OVERVIEW
All five of the redesigned lighting spaces have been modified to be supplied by the Ransom Center's 277/480V system. These spaces were previously supplied by a 120 volt system, which served the building well primarily because most of the fixtures were incandescent or low voltage halogen sources. Power density requirements are far more likely to be enforced today than in 2003, and likewise ASHRAE power density requirements are more stringent.

To save energy, lighting in the redesigned spaces has been changed to fluorescent, compact fluorescent and metal halide sources. Low voltage halogen lighting was used only when lighting critical artwork, which is exempt from power density calculations per ASHRAE 90.1 standards. The new lamp selections allow these spaces to easily be supplied by 277 volt branch circuits (most low voltage halogen sources have been selected to house a 277 volt electronic dimming transformer). All new dimming and switched panelboards have been specified as 277 volt, except for Panel LT-1, which serves the gallery monopoint fixtures at 120 volts.

Panel LD-1 Schedule

PANEL LD-1		**North Electrical Closet**				
DIMMER	ZONE	TYPE	CONTROL	LOAD (kW)	VOLTAGE (V)	LOCATION
1	Z1	CFL	Timeclock	0.12	277	Entry Vestibule
2	Z2	CFL	Dim	0.627	277	Lobby
3	Z3	CMH	Timeclock	1.5675	277	Lobby
4	Z4	CHM	Timeclock	1.454	277	Lobby
5	Z5	Low Voltage	Dim	0.15	277	Lobby
6	Z6	Fluorescent	Dim	0.072	277	Lobby
7	Z7	Low Voltage	Dim	0.6	277	Lobby
8	Z8	Low Voltage	Dim	0.15	277	Lobby
9	Z19	Low Voltage	On/Off	0.544	277	Lobby Ramp
10	Z19	CMH	Dim	0.15	277	Lobby Bible Display
11	Z20	LED	DMX	0.12	277	Entry Vestibule
12	Z64	MR-16	Dim	0.02	277	Lobby First Photo Display
13	Z21	CMH	Timeclock	0.264	277	Exterior Canopy
14	Z27	Low Voltage	Timeclock	0.18	277	Exterior In-Grade
15	Z28	Fluorescent	Timeclock	0.324	277	Exterior
16	Z29	Fluorescent	Timeclock	0.248	277	Exterior
17	Z30	Fluorescent	Timeclock	0.186	277	Exterior
18		OPEN				
19		OPEN				
20		OPEN				
21		OPEN				
22		OPEN				
23		OPEN				
24		OPEN				
		TOTAL LOAD (kw)		6.7765		
		Growth Factor		8.47		

Panel LD-1 Breaker Sizing

I = (8.47 KVa) / (3 * 277)
I = 10.2 A

Use 60A breaker

Panel LD-2 Schedule

PANEL LD-2		**North Electrical Closet**				
DIMMER	ZONE	TYPE	CONTROL	LOAD (kW)	VOLTAGE (V)	LOCATION
1	Z11	CFL	Timeclock	0.24	277	North Hall
2	Z12	Low Voltage	Timeclock	1.05	277	North Hall
3	Z13	Low Voltage	Dim	0.075	277	North Hall
4	Z14	Low Voltage	Dim	0.06	277	North Hall
5	Z15	Low Voltage	Dim	0.075	277	North Hall
6	Z16	Low Voltage	Dim	0.06	277	North Hall
7	Z25	CMH	Timeclock	0.955	277	Theatre Lobby
8	Z26	LED	DMX	4.32	277	Theatre Lobby
9	Z30	Low Voltage	Dim	0.7	277	Theatre
10	Z31	Low Voltage	Dim	0.7	277	Theatre
11	Z32	Low Voltage	Dim	0.7	277	Theatre
12	Z33	Low Voltage	Dim	0.8	277	Theatre
13	Z34	Low Voltage	Dim	0.8	277	Theatre
14	Z35	Fluorescent	Dim	0.385	277	Theatre
15	Z36	Fluorescent	Dim	0.385	277	Theatre
16		OPEN				
17		OPEN				
18		OPEN				
19		OPEN				
20		OPEN				
21		OPEN				
22		OPEN				
23		OPEN				
24		OPEN				
		TOTAL LOAD (kw)		11.305		
		Growth Factor		14.13		

Panel LD-2 Breaker Sizing

I = (14.13 KVa) / (3 * 277)
I = 17.0 A

Use 60 A breaker

Panel LD-3 Schedule

PANEL LD-3		**South Electrical Closet**				
DIMMER	ZONE	TYPE	CONTROL	LOAD (kW)	VOLTAGE (V)	LOCATION
1	Z9	CFL	Timeclock	0.18	277	South Hall
2	Z10	Low Voltage	Timeclock	1.05	277	South Hall
3	Z17	LED	DMX	0.036	277	South Hall / Elevator Threshold
4	Z22	CFL	Timeclock	0.22	277	Stair Hall
5	Z23	CMH	Timeclock	0.955	277	Stair Hall
6	Z24	LED	DMX	4.32	277	Stair Hall
7		OPEN				
8		OPEN				
9		OPEN				
10		OPEN				
11		OPEN				
12		OPEN				
		TOTAL LOAD (kw)		6.761		
		Growth Factor		8.45		

Panel LD-3 Breaker Sizing

I = (8.45 KVa) / (3 * 277)
I = 10.20 A

Use 60 A breaker

Panel LT-1 Schedule

PANELBOARD SCHEDULE

VOLTAGE: 208Y/120V,3PH,4W
SIZE/TYPE BUS: 70A
SIZE/TYPE MAIN: 60A/3P C/B

PANEL TAG: LT-1
PANEL LOCATION: South Electrical Closet
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 14KA
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Monopoint	Gallery	2100	20A/1P	1	*			2	20A/1P	2100	Gallery	Monopoint
Monopoint	Gallery	2100	20A/1P	3		*		4	20A/1P	2100	Gallery	Monopoint
Monopoint	Gallery	2100	20A/1P	5			*	6	20A/1P	2550	Gallery	Monopoint
		0	20A/1P	7	*			8	20A/1P	900	Gallery	Monopoint
Monopoint	Gallery	1800	20A/1P	9		*		10	20A/1P	0		0
Monopoint	Gallery	900	20A/1P	11			*	12	20A/1P	0		0
0		0	20A/1P	13	*			14	20A/1P	0		
		0	20A/1P	15		*		16	20A/1P	0		
		0	20A/1P	17			*	18	20A/1P	0		
		0	20A/1P	19	*			20	20A/1P	0		
		0	20A/1P	21		*		22	20A/1P	0		
		0	20A/1P	23			*	24	20A/1P	0		
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	5.10	TOTAL DESIGN LOAD (KW)	20.81
CONNECTED LOAD (KW) - B	6.00	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	5.55	TOTAL DESIGN LOAD (AMPS)	58

Panel LT-2 Schedule

PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W
SIZE/TYPE BUS: 500A
SIZE/TYPE MAIN: 500A/3P C/B

PANEL TAG: LT-1
PANEL LOCATION: South Electrical Closet
PANEL MOUNTING: SURFACE

MIN. C/B AIC: 14KA
OPTIONS:

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Track	Gallery	13296	60A/1P	1	*			2	60A/1P	13296	Gallery	Track
Track	Gallery	13296	60A/1P	3		*		4	60A/1P	13296	Gallery	Track
Track	Gallery	13296	60A/1P	5			*	6	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	7	*			8	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	9		*		10	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	11			*	12	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	13	*			14	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	15		*		16	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	17			*	18	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	19	*			20	20A/1P	13296	Gallery	Track
Track	Gallery	13296	20A/1P	21		*		22	20A/1P	13293	Gallery	Track
Track	Gallery	13293	20A/1P	23			*	24	20A/1P	13296	Gallery	Track
		0	20A/1P	25	*			26	20A/1P	0		
		0	20A/1P	27		*		28	20A/1P	0		
		0	20A/1P	29			*	30	20A/1P	0		
		0	20A/1P	31	*			32	20A/1P	0		
		0	20A/1P	33		*		34	20A/1P	0		
		0	20A/1P	35			*	36	20A/1P	0		
		0	20A/1P	37	*			38	20A/1P	0		
		0	20A/1P	39		*		40	20A/1P	0		
		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	106.37	TOTAL DESIGN LOAD (KW)	398.87
CONNECTED LOAD (KW) - B	106.37	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	106.37	TOTAL DESIGN LOAD (AMPS)	480

3.3 FEEDER SCHEDULE

OVERVIEW
Feeders to new panelboards were sized based upon their demand loading. Modifications to existing panelboards and feeders were also resized as needed. The following table summarizes redesigned feeder sizing for the Harry Ransom Center.

Feeder Schedule

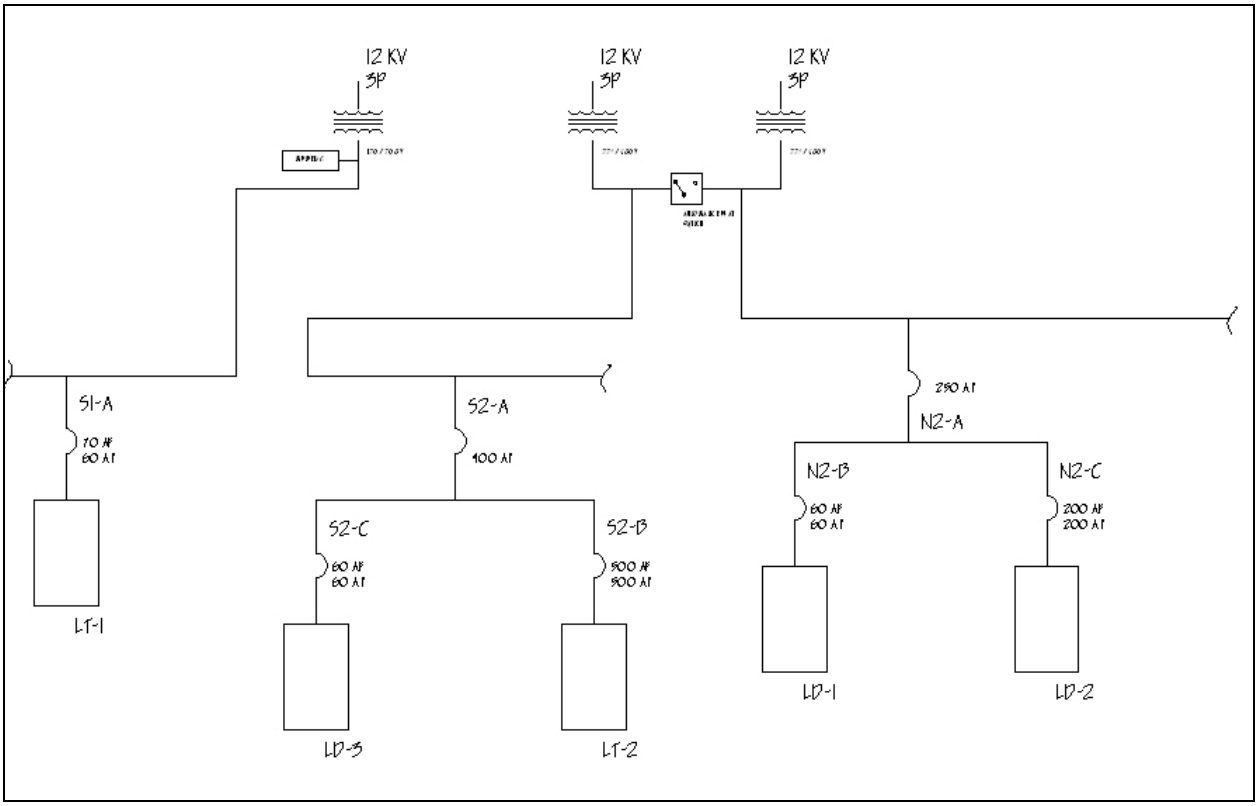
FEEDER SCHEDULE

TAG	FROM	TO	NO. OF SETS	CONDUIT (PER SET) SIZE	CONDUIT (PER SET) TYPE	CONDUCTORS (PER SET) PHASE CONDUCTORS No.	PHASE CONDUCTORS SIZE	PHASE CONDUCTORS TYPE	NEUTRAL CONDUCTORS No.	NEUTRAL CONDUCTORS SIZE	NEUTRAL CONDUCTORS TYPE	GROUND CONDUCTORS No.	GROUND CONDUCTORS SIZE	GROUND CONDUCTORS TYPE	SIZE OF OVERCURRENT PROTECTION	FRAME OR SWITCH SIZE	REMARKS
1	MDP-N	LD-1	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	8AWG	AL THWN	60	60A/3P	
2	MDP-N	LD-2	1	2-1/2"	EMT	3	250KCMIL	AL THWN	1	250KCMIL	AL THWN	1	4AWG	AL THWN	200	200A/3P	
3	BLS	LT-1	1	1-1/4"	EMT	3	3AWG	AL THWN	1	3AWG	AL THWN	1	6 AWG	AL THWN	60	70A/3P	
4	MDP-S	LT-2	2	3-1/2"	EMT	3	350KCMIL	AL THWN	1	350KCMIL	AL THWN	1	2AWG	AL THWN	500	500/3P	
5	MDP-S	LD-3	1	1-1/4"	EMT	3	4AWG	AL THWN	1	4AWG	AL THWN	1	8AWG	AL THWN	60	60A/3P	

NOTES:
1. REFER TO RISER DIAGRAM FOR FEEDER TAGS

AL=ALUMINUM
CU=COPPER

Single Line Diagram



Please note that a single line diagram for the existing electrical systems was not provided by the electrical engineers. Consequently, some feeder sizes and arrangements were assumed. The illustrated single line diagram only incorporates the circuitry for redesigned and modified panelboards.

3.4 FEEDER COMPARISON STUDY

OVERVIEW

In this section of electrical breadth work, a cost analysis of copper to aluminum feeders is compared. The purpose of this exercise was to determine whether specifying aluminum feeders would provide a reduction in overall building cost.

Source for material and installation costs: RS Means, *Electrical Cost Data 2007* P. 112-113.

Comparing Copper vs. Aluminum

Feeder Tag	From	To	Length (Ft)	Protection (A)	No. of Sets	Phase/Neutral				Ground				Conduit				Cost	
						Copper		Aluminum		Copper		Aluminum		Copper		Aluminum			
						Size	Cost/lf	Size	Cost/lf	Size	Cost/lf	Size	Cost/lf	Size	Cost/lf	Size	Cost/lf		
1	MDP-N	LD-1	48	60	1	6	1.15	4	1.15	10	0.82	8	0.85	1"	11.10	1-1/4"	12.90	792.96	880.8
2	MDP-N	LD-2	48	200	1	4/0	8.15	250	4.20	6	1.63	4	1.15	2-1/2"	27.00	2-1/2"	27.00	2939.04	2157.6
3	BLS	LT-1	93	60	1	4	2.29	3	1.45	8	1.15	6	0.94	1-1/4"	12.90	1-1/4"	12.90	2158.53	1826.52
4	MDP-S	LT-2	93	490	2	250	9.25	350	4.95	4	2.29	2	1.85	2-1/2"	27.00	2-1/2"	27.00	12329.94	9048.9
5	MDP-S	LD-3	93	60	1	6	1.15	4	1.15	10	0.82	8	0.85	1"	11.10	1-1/4"	12.90	1536.36	1706.55
6	DPE (2)	HE1	122	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	7661.6	5666.9
7	LDA	BLS	30	600	2	350	12.25	500	6.50	1	3.90	2	1.85	3"	36.00	3"-0"	36.00	5334	3831
8	1LD	Unknown	35	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	2198	1625.75
9	1LC	Unknown	35	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	2198	1625.75
10	1HB	Unknown	35	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	2198	1625.75
11	1HA	Unknown	35	100	1	2	3.20	1/0	2.42	8	1.15	6	0.94	1-1/4"	12.90	1-1/2"	14.40	939.75	875.7
12	LDB	BLN	30	400	2	350	12.25	500	6.50	1	3.90	2	1.85	3"	36.00	3"-0"	36.00	5334	3831
13	1LB	Unknown	35	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	2198	1625.75
14	1LE	Unknown	35	100	1	2	3.20	1/0	2.42	8	1.15	6	0.94	1-1/4"	12.90	1-1/2"	27.00	939.75	1316.7
15	1LE-2	Unknown	35	100	1	2	3.20	1/0	2.42	8	1.15	6	0.94	1-1/4"	12.90	1-1/2"	27.00	939.75	1316.7
16	LTA	LDA	56	150	1	1/0	4.50	3/0	3.05	6	1.63	4	1.15	2"	17.85	2"	17.85	2098.88	1747.2
17	LTB	LDA	56	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2'-1/2"	27.00	2-1/2"	27.00	3516.8	2601.2
18	LTC	LDA	56	150	1	1/0	4.50	3/0	3.05	6	1.63	4	1.15	2"	17.85	2"	17.85	2098.88	1747.2
19	LTD	LDA	56	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	3516.8	2601.2
20	LTE	LDA	56	225	1	4/0	8.15	300	4.40	2	3.20	2	1.85	2-1/2"	27.00	2-1/2"	27.00	3516.8	2601.2
															Cost Comparison (USD)			**64445.84**	**50259.37**

DISCUSSION

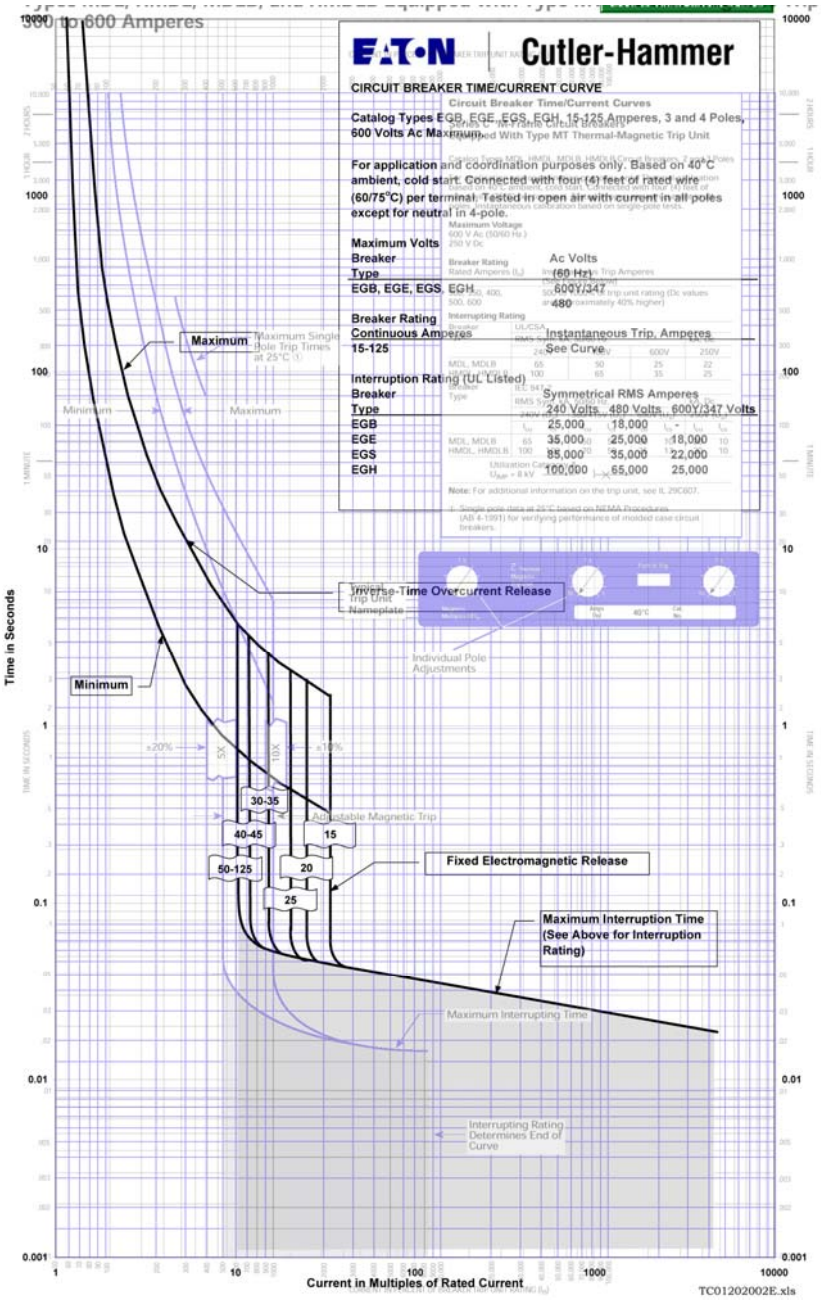
As is demonstrated in this schedule, overall cost of feeders and related installation is reduced from $64,446 to $50,529. This is a $14,186 reduction in cost, or a savings of twenty-two percent.

Although a more comprehensive study incorporating a look into construction coordination issues should be undertaken to determine if this savings can be realized, based upon the data provided it would make since to use aluminum feeders. The considerably high cost reduction indicates there may be a cost savings if this building were under construction in 2007.

3.5 PROCTIVE DEVICE COORDINATION STUDY

OVERVIEW

A time coordination study is demonstrated in the below figure. A single path from dimming panel LD-3 through feeder S2-A to the corresponding bus was selected for investigation. Circuit breaker sized at 60 Amperes and 500 Amperes, are located along this path. Blue denotes the 500 Ampere breaker and black is used to illustrate the 60 Ampere breaker.



DISCUSSION

It appears that these two breakers are in coordination; under lower currents, the 60 ampere breaker will trip first under both fast and slow conditions. During high current load, the 500 ampere breaker will trip nearly immediately.

It should be noted that general assumptions were made in this exercise, and additional information was not furnished by the electrical engineers to continue with the investigation of this study. The circuit breaker sizes for the primary transformer were not provided, and likewise it is unknown whether devices are located on primary or transformer sides. More information must be provided to make any further conclusions or studies.