



ELECTRICAL DEPTH

CURRENT SYSTEM

The current electrical system can best be described as star; one main switchboard that feeds to the main distribution panel, which then feeds the other panels. The normal power is provided to the existing Assisted Living Facility from a PEPCO owned network transformer vault. The electrical service terminates in a 2000 amp, Square-D switchboard protected by a fused bolted pressure switch located in the basement of the Assisted Living Facility. From the switchboard, power is fed to the distribution panel board, designated Panel MDP, rated 480Y/277 volts, 3 phase, 600A. Mechanical equipment is served directly from Panel MDP. Lighting and receptacle loads are served by dry-type transformers and 208Y/120 panelboards. The distribution panels are located in the Penthouse area of the Assisted Living Facility and panelboards are fed down from that location.

The emergency power is generated via and on-site, 150 KW diesel-fired emergency generator. The generator is located outside on grade, and provides emergency power to the egress lighting and a limited amount of refrigeration in the kitchen. Emergency power for the addition is provided for the egress lighting, and is received from the existing emergency distribution panel EH1. Emergency power is stepped down to 208Y/120 voltage and distributed to life safety panels on floors 2 and 4 of the addition.

A calculation of the NEC building design load was performed to check the existing wire sizes and over current protection devices for the main feeders and distribution panels. Look at Technical Assignment #1, located on the course website for these calculations. The addition will be built and metered under the rate schedule of “GT-LV”, Time Metered General Service – Low Voltage Service Schedule, which is a different rate structure than that of the existing building.

NEW DESIGN CONSIDERATION

The existing Assisted Living Facility receives chilled water for cooling and medium pressure steam for heating from Sibley Memorial Hospital’s center plant. It is the intent of both the electrical and mechanical design that I suggest implementing, to make this addition a stand alone facility. One way to help make this addition a stand alone facility electrically is to segregate the electricity it receives and make it somewhat independent of the existing building. There were two options that I first considered. The first would have been to provide another PEPCO owned transformer, from which the new addition would be served. After preliminary talks with an electrical engineer, I opted against this due to a high initial cost of acquiring a new service, and the fact that it would increase the electric bill given that the two buildings would have separate meters, and incur several duplicate charges with such an option.



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The option for my design was to add a section to the existing switchboard, and extend one normal power feeder over to the addition, that would serve a Main Distribution Panel, denoted MDP, from which all subsequent distribution panels would be served, in addition to the two elevators and the water-to-water heat pumps associated with the Energy Recovery Air Handling Unit. One reason this was not done in the current design was because of the strain that the starting load of the roof-top chiller would put on the electrical system. Every time the chiller turned on, there could be a dip in the voltage supplied resulting in a flicker in the lights and other electrical devices in the addition. Obviously, if the feeders were oversized considerable to handle the starting load, it would not be a problem, but that would not be cost effective. This does make sense in my design given the fact that I have eliminated the roof top chiller as the cold water provided. With the use of water-to-air heat pumps in the tenant suites and water-to-water heat pumps for the Energy Recover Air Handling Unit, I will eliminate the inrush current that the chiller would have provided. Another reason for this design consideration is to explore the cost savings that could be realized by reducing the number of feeders and underground duct bank that would need to be installed to extend service from the existing building to the addition.

In my mechanical feasibility study, I considered replacing the 4-pipe fan coil units with 2-pipe water-to-air heat pumps. The fan-coil units are served from 480Y/277V, 3-phase, 4-wire, 100 A panels, located on floors 2-4. The first thing I had to do for the electrical design was to check the connected load that the heat-pumps would put on these panels and make sure that the connected load did not exceed the allowable load for these given panels, as well as making sure there was room for system growth. I did two calculations to make sure the panels are sized appropriately for the heat-pump loads. First, I found the total kw that 89 heat-pumps produced, and assuming that each of the three paneboards would have about equal connected load, I could see if they were sized appropriately. I also looked at the individual panelboards; H2-NE, H3-NE, H4-NE, and gave each of the 89 heat pumps their own circuit, spread over the 3 panels, to make sure the general calculation was acceptable. The electrical characteristics of the heat-pumps are referenced in Appendix B. The panel boards; H2-NE, H3-NE, and H4-NE, are referenced in Appendix C, which show the respective connected loads that the heat pumps place on the panels.

GENERAL CALCULATION FOR LOAD ON PANELS H2-NE, H3-NE, H4-NE

Total of 136.0347 kw from heat pumps serving tenant suites and additional spaces.

- $136.0347 \text{ kw} = \sqrt{3} * (480) * A$
- Amps = 163.624 A
- Assuming about an equal load on each floor
- $163.624/3 = 54.54 \text{ A per panel @ } 480 \text{ V} - 3\phi$
- 100 amp panel can hold 80 amps of load
- $54.54 * 1.25(\text{growth}) = 68.175 \text{ A}$



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- $68.175 \times 1.25(\text{Ckt Bkr}) = 85.21875$ – use 100 A circuit breaker
- Therefore, you can use the 100 amp panels that are currently serving these floors
- Using 4#3 + 1#8 GRND/ panel
 - #3 = 100 amps of allowable ampacity
 - *This calculation tells me that I can maintain the panels as they are and connect the Heat-Pump loads in place of the Fan-Coil Units*

An example of the calculation to check for panel and wire size is provided below. For each panel, the largest load on any single phase was chosen for analysis, and if this complied, by default, the other two phase loads were acceptable.

EXAMPLE CALCULATION: CHECKING PANEL H2-NE

WIRING PANEL SCHEDULE																	
PANEL: H2-NE			MAINS: MLO									AMPS: 100			AIC: 14K		
VOLTAGE: 480Y/277V			WIRES: 4			PHASE: 3						MOUNTING: SURFACE			LOC: 2ND FLR. EAST		
CIR	DESCRIPTION	P	AMP	BRANCH CIRCUIT	A	A	B	B	C	C	CIR	DESCRIPTION	P	AMP	BRANCH CIRCUIT		
1	HP-2-1	1	15	3/4"C.W/2#12+1#12GRD.	5	5	-	-	-	-	2	HP-2-13	1	15	3/4"C.W/2#12+1#12GRD.		
3	HP-2-2	1	15	3/4"C.W/2#12+1#12GRD.	-	-	5.5	5.5	-	-	4	HP-2-14	1	15	3/4"C.W/2#12+1#12GRD.		
5	HP-2-3	1	15	3/4"C.W/2#12+1#12GRD.	-	-	-	-	5.5	5.5	6	HP-2-15	1	15	3/4"C.W/2#12+1#12GRD.		
7	HP-2-4	1	15	3/4"C.W/2#12+1#12GRD.	5.5	7.1	-	-	-	-	8	HP-2-16	1	15	3/4"C.W/2#12+1#12GRD.		
9	HP-2-5	1	15	3/4"C.W/2#12+1#12GRD.	-	-	7.1	7.1	-	-	10	HP-2-17	1	15	3/4"C.W/2#12+1#12GRD.		
11	HP-2-6	1	15	3/4"C.W/2#12+1#12GRD.	-	-	-	-	7.1	5	12	HP-2-18	1	15	3/4"C.W/2#12+1#12GRD.		
13	HP-2-7	1	15	3/4"C.W/2#12+1#12GRD.	5	5	-	-	-	-	14	HP-2-19	1	15	3/4"C.W/2#12+1#12GRD.		
15	HP-2-8	1	15	3/4"C.W/2#12+1#12GRD.	-	-	5	3.6	-	-	16	HP-2-20	1	15	3/4"C.W/2#12+1#12GRD.		
17	HP-2-9	1	15	3/4"C.W/2#12+1#12GRD.	-	-	-	-	3.6	3.6	18	HP-2-21	1	15	3/4"C.W/2#12+1#12GRD.		
19	HP-2-10	1	15	3/4"C.W/2#12+1#12GRD.	3.6	3.6	-	-	-	-	20	HP-2-22	1	15	3/4"C.W/2#12+1#12GRD.		
21	HP-2-11	1	15	3/4"C.W/2#12+1#12GRD.	-	-	3.6	3.6	-	-	22	HP-2-23	1	15	3/4"C.W/2#12+1#12GRD.		
23	HP-2-12	1	15	3/4"C.W/2#12+1#12GRD.	-	-	-	-	3.6	3.6	24	HP-2-24	1	15	3/4"C.W/2#12+1#12GRD.		
25	HP-NE - BRIDGE	1	20	3/4"C.W/2#12+1#12GRD.	11.4	3.6	-	-	-	-	26	HP-2-25	1	15	3/4"C.W/2#12+1#12GRD.		
27	HP-NW - BRIDGE	1	20	3/4"C.W/2#12+1#12GRD.	-	-	11.4	11.4	-	-	28	HP-2-1-DAY/ACTIVITY ROOM	1	20	3/4"C.W/2#12+1#12GRD.		
29	HP-2-2-DAY/ACTIVITY ROOM	1	20	3/4"C.W/2#12+1#12GRD.	-	-	-	-	11.4	0	30	SPARE	1	20	-		
31	SPARE	1	20	-	0	0	-	-	-	-	32	SPARE	1	20	-		
33	SPACE	1	-	-	-	-	0	0	-	-	34	SPACE	1	-	-		
35	SPACE	1	-	-	-	-	-	-	0	0	36	SPACE	1	-	-		
37	SPACE	1	-	-	0	0	-	-	-	-	38	SPACE	1	-	-		
39	SPACE	1	-	-	-	-	0	0	-	-	40	SPACE	1	-	-		
41	SPACE	1	-	-	-	-	-	-	0	0	42	SPACE	1	-	-		
CONNECTED LOAD		0 A		TOTAL PHASE A	22 A												
DEMAND LOAD		0 A		TOTAL PHASE B	30 A												
25% GROWTH		0 A		TOTAL PHASE C	26 A												



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A 100A – 3-phase can have up to 100 amps connected on any single phase. It is design practice to connect a maximum load of 80% of what the panel is rated.

- $30A * 1.25(\text{demand}) * 1.25(\text{growth}) = 46.875A < 100A \text{ per phase}$

-

The panels are served by 4#3+1#8GRND, check to make sure wires have enough ampacity

- *Ampacity of #3THW, 75°C = 100 A*

- *De-rate the wire – $100 * 0.8 = 80 A > 46.875$ therefore, panel can handle the connected load of the Heat-Pumps*

- *Remaining two panels loads were also sized appropriately to handle heat-pump loads.*

SIZING A MAIN DISTRIBUTION PANEL

- 1.) I need to find the amps associated with the existing Main Distribution Panel (MDP). From the previous check of adding the heat-pumps in place of the fan-coil units to the existing panel boards, I know that I am not exceeding the VA allocated for those panels, and I have not added any additional load to the existing MDP, therefore...

- Existing 600A panel
- De-rate to find ampacity

$$600A * 0.8 = 480 A$$

- $480A + 128A + 80A = 688 A$

Elevators FLA given from cutsheet data from manufacturer – provided by electrical engineer – 64 FLA/Elevator motor

FLA from Heat Pumps associated with Energy Recovery Unit. These are provided to give additional capacity to the horizontal loop when heating and cooling coils are needed to condition the outdoor air to appropriate temperatures and

- Circuit Breaker Size = $1.25 * 688 = 860 A$ – this is not a standard size, so step up to a **900A breaker**, - it will have a 900 A trip mechanism, but fits in a 100A frame.
- Provide a Square-D I-line **1000A Panelboard**



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FEEDER SIZING

- Find an insulated conductor with **900A** allowable ampacity
- Use **(3) sets of 350 MCM** – [table 310.16 NEC 2002]
 - **350MCM** has an ampacity of **310A*3 = 930A > 900A O.K.**
- Provide **1#2/0 Ground** for each set of **350 MCM** [table 250.122 NEC 2002]

VOLTAGE DROP

- Distance = 310 feet from duct bank take-off, round up to **400 feet** to be conservative
- To be conservative, using full load as **80%*900A** ckt bkr = 720 FLA

$$VD = \frac{(720)(400)(106)}{(3)(480)(10,000)} \leftarrow \text{Chart value}$$

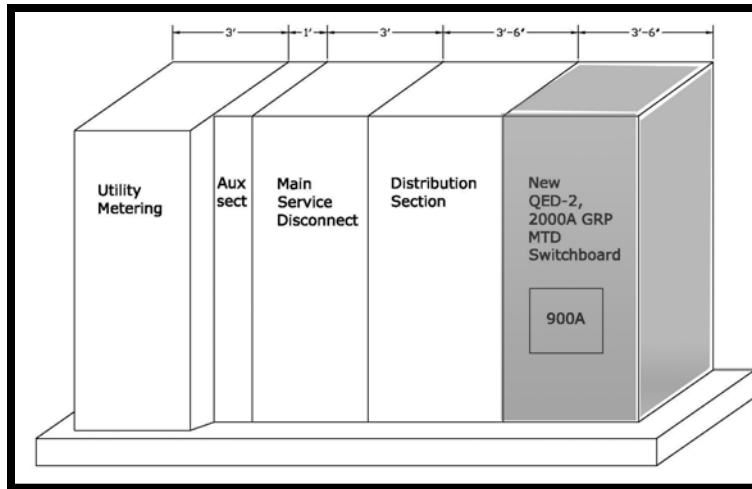
$$VD = 2.1\% < 3\% \text{ O.K [article 215.2 FPN No.2]}$$

DISTRIBUTION SECTION

- Currently there is a **2000A** Switchboard with **2000A** horizontal bus, and **2000A** vertical bus
- Need to add a **2000A** section to existing Square-D Switchboard
- Provide **QED-2, 2000A** Group Mounted Switchboard, Floor Mounted, **480Y/277V**
- Install **900A** circuit breaker



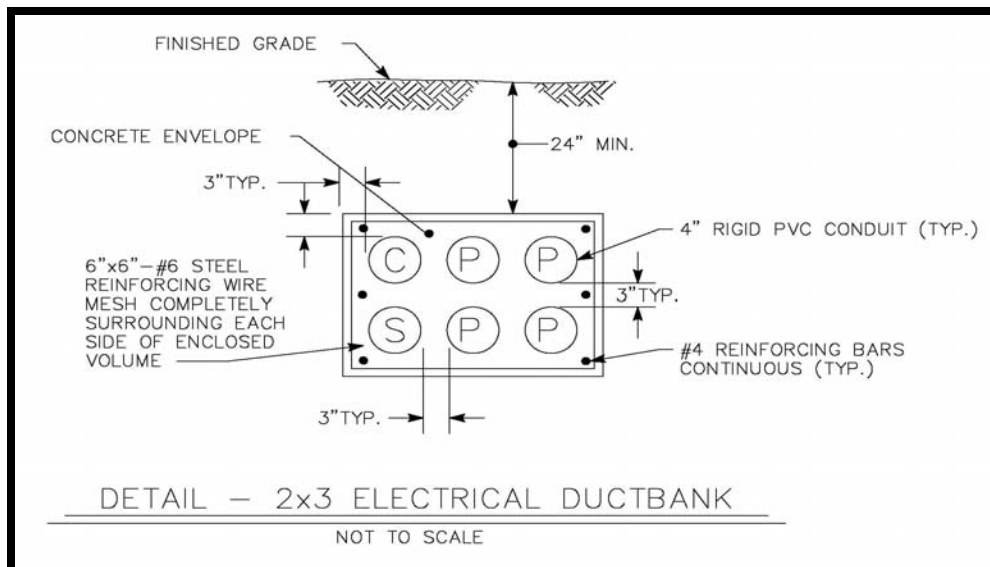
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Schematic of new 2000A Group Mounted Switchboard.

DUCTBANK

- Provide (6) – 4” conduits, 2 rows of 3 stacked
 - NEC says that you could use 3”, but 4” is the standard used in industry, therefore that is what will be specified
- 3 normal power conduits to house (3)sets of 4#350MCM + 1#2/0GRND
- 1 emergency power conduit to house 4#1+1#8



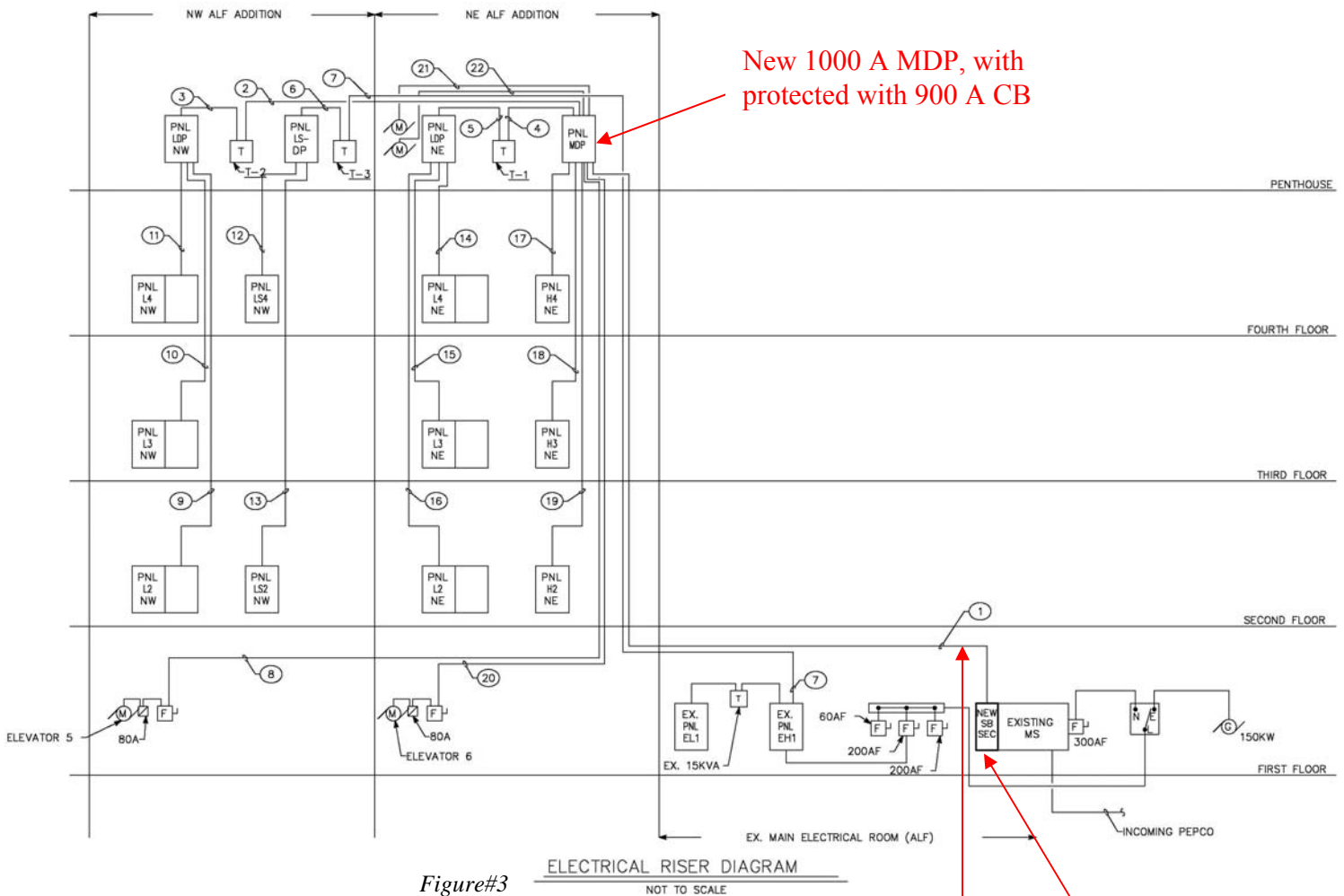
Schematic of electrical ductbank



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Now that all items are sized and specified, a new riser diagram can be developed to show the implementation of the new design.

New Electrical Riser Diagram



Figure#3

ELECTRICAL RISER DIAGRAM
 NOT TO SCALE

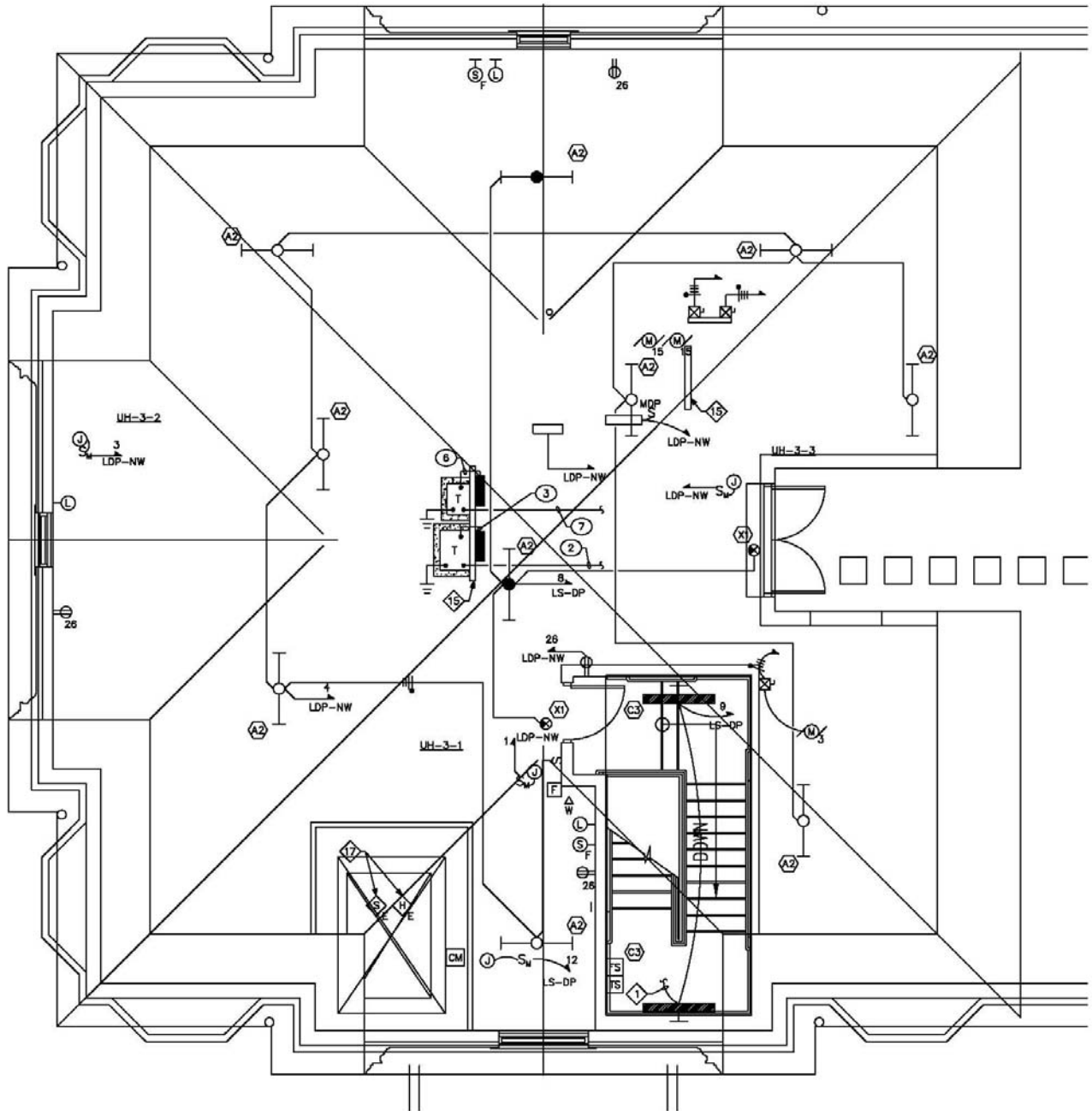
NOTE: Refer to Feeder Schedule in Appendix C for associated changes with this new distribution section; the highlighted numbers are the feeders that differ from the original design.

Single Feeder Extended to New Building Addition – (3) sets – 350 MCM in underground duct bank



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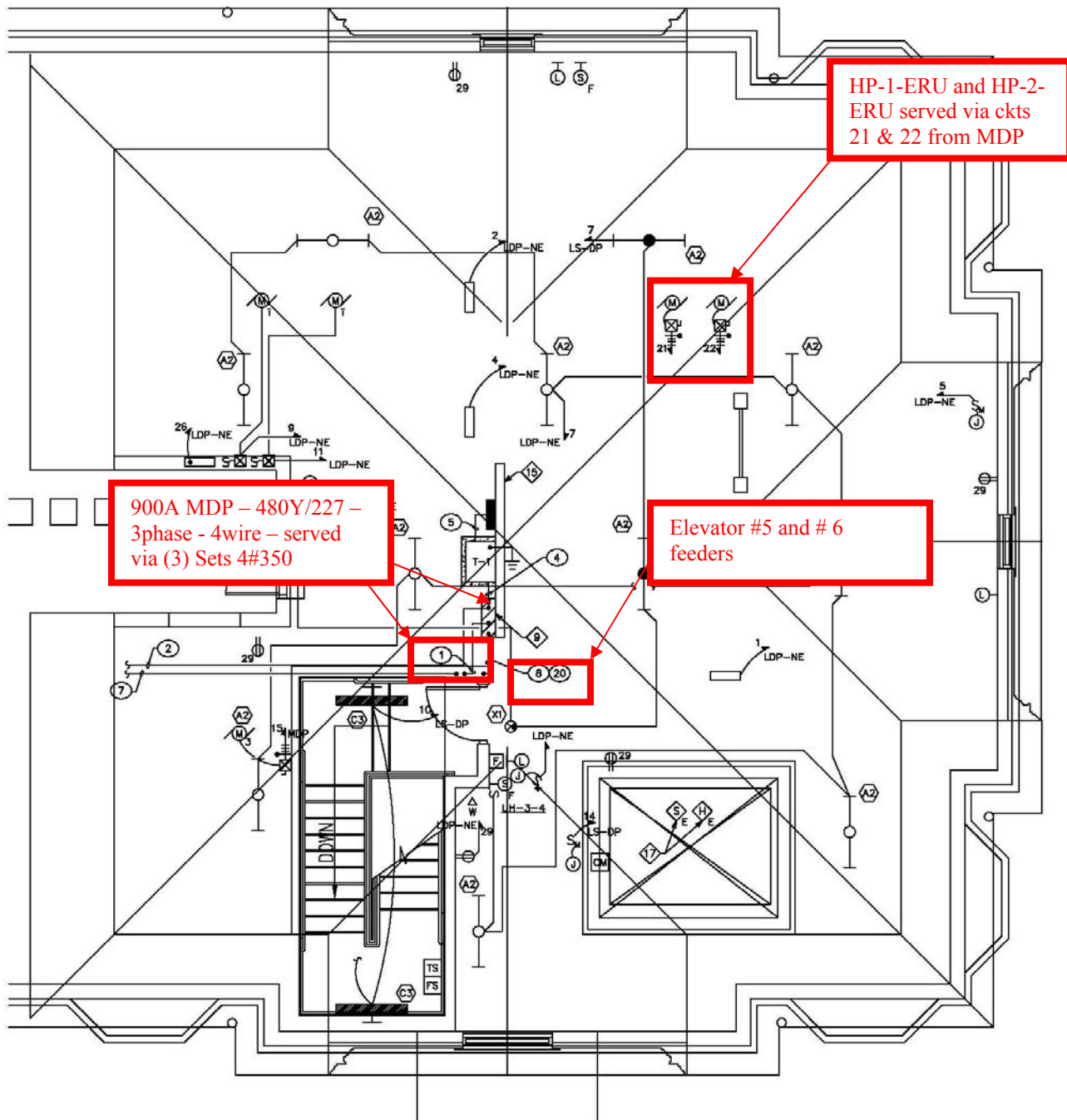
NW - Penthouse Electrical Plan





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NW - Penthouse Electrical Plan





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The purpose of this new electrical distribution plan is to see what if any cost savings can be associated with this design, based on a new configuration that was made possible by geothermal heat pump installation that was suggested in the Mechanical Feasibility Study Report. As well as provide another way to segregate the addition from the existing building. Below are the cost comparisons of the two systems. It summarizes and depicts the differences in cost of the circuit breakers, Main Distribution panels, feeders, etc.

COST COMPARISON – CURRENT DISTRIBUTION SYSTEM

Current System							
Breakers (3-phase)							
16410 Encl Switches & Circuit Breakers		Size (A)	Quantity	Cost/unit	Cost	Total Incl. O&P	
	220 0600	150	2	\$4,100	\$8,200	\$9,929.10	
	200 0700	350	1	\$4,600	\$4,600	\$5,761.50	
	200 0800	600	1	\$6,400	\$6,400	\$7,986.75	
					Subtotal	\$23,677.35	
MDP							
16440 Swbds, Panels & Control Centers		Size (A)	Quantity	Cost/unit	Total	Total Incl. O&P	
	820 0900	600	1	\$4,000	4808.15	\$4,808.15	
Feeders							
16120 Conductors & Cables		Wire	Quantity	Length	Total/C.L.F	Total Incl. O&P	
	900 0490	500 MCM	8	400	624	\$24,480.00	
	900 0400	250 MCM	3	400	379	\$5,760.00	
	900 0300	3/0.	6	400	276	\$8,520.00	
	900 0240	#1	4	400	161.5	\$3,344.00	
	900 0200	#3	2	400	115	\$1,216.00	
					Subtotal	\$43,320.00	
Ductbank							
16132 Conduit in Trench		240 1000	Quantity	Length	Total/L.F	Total Incl. O&P	
Includes terminations and fittings does not include excavation or backfill, see div. 02315		4" diameter	60" wide	400	415	\$166,060.00	
4" conduit in a duct bank is an industry standard, therefore that is what was used in the cost comparison						Total Cost	\$237,865.50



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COST COMPARISON –PROPOSED DISTRIBUTION SYSTEM

Proposed System						
Breakers (3-phase)						
16410 Encl Switches & Circuit Breakers		Size (A)	Quantity	Cost/unit	Cost	Total Incl. O&P
	900A-trip	1000	1	\$14,000	\$14,800	\$17,020.00
		40	2	\$1,088	\$2,380	\$2,737.00
					Subtotal	\$19,757.00
MDP						
16440 Swbds, Panels & Control Centers		Size (A)	Quantity	Cost/unit	Total	Total Incl. O&P
	820 0900	1000	1	\$8,000	\$8,410	\$9,200
Switchboard Section						
16440 Swbds, Panels & Control Centers		Size (A)	Quantity	Cost/unit	Total	Total Incl. O&P
	840 5000	2000	1	\$9,950	\$10,910	\$12,000
Feeders						
16120 Conductors & Cables		Wire	Quantity	Length	Total/C.L.F	Total Incl. O&P
	900 0450	350 MCM	12	400	478	\$28,560.00
	900 0280	2/0	3	400	230	\$3,552.00
	900 0200	# 3	6	150	110	\$1,217.40
	900 140	# 8	8	200	50.3	\$1,080.00
	900 120	#10	2	50	50	\$50.00
					Subtotal	\$34,459.40
Ductbank						
16132 Conduit in Trench		240 1000	Quantity	Length	Total/L.F.	Total Incl. O&P
		4" diameter	36"	400	253	\$101,200.00
Includes terminations and fittings does not include excavation or backfill, see div. 02315						
4" conduit in a duct bank is an industry standard, therefore that is what was used in the cost comparison						
					Total Cost	\$176,616.40

In this cost comparison, the electrical distribution system that I propose will save around **\$61,250**. The numbers for associated cost were found in R.S. Means. The way in which the



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numbers were quantified was kept consistent between the two comparisons so that if any one item has a discrepancy, the one in which it is being compared to has the same discrepancy, hence maintaining the same margin of error for each comparison comparison. As one can see by looking at the two cost comparisons, the biggest difference occurs when comparing the size of the duct bank, which is priced per linear foot based on the size of the duct. By reducing the number of feeders that are extended over to the addition from the Main Electrical Room in the existing building, I can reduce the number of conduits needed, thereby reducing the size of the ductbank to carry those feeders.

Conclusion

To conclude, the existing design extended four normal power feeders from the existing, 2000 amp Switchboard, two of those feeders served Elevators #4 and #5, one of those feeders served a 180kw Roof Top Rotary Screw Chilling Unit, and one served the 600A MDP. With my proposed mechanical design, the Roof Top Chiller was eliminated, thereby removing any concern for a sag in the electrical voltage seen by other equipment in the building during the Chiller start-up period. It is assumed based on the characteristics of the heat-pumps, which were thoroughly explain in the Mechanical Feasibility Study, that at no time will they *all* be operating, starting, or stopping. However, with the Chiller running at full capacity during the extreme design days, i.e. – a very hot and humid day, pulling 180kw of power, a large strain would have been placed on my design by only extending one normal power feeder to a MDP. Therefore, by re-evaluating the Mechanical System and suggesting an alternative method for heating and cooling, I was able to reduce the cost associated with the Electrical Distribution System, and save approximately \$61,250.