Electrical Depth

Overview:

Electrical service is provided to the Franklin Care Center at 480/277V and 208/120V. The 480/277 voltage serves most of the lighting and mechanical equipment, however the voltage must be stepped down to 208/120V to serve the equipment on the emergency critical distribution panelboard as well as on the receptacle distribution panelboard. One step down transformer is located directly before each of these distribution boards to step the voltage down for all of the panel boards served by that distribution board.

Problem Statement:

By using one transformer per distribution panel, all conductors that run from that distribution panelboard to the panels carries load at 208/120V. This makes the ampere rating of the circuits larger than if it were fed with 480/277V load.

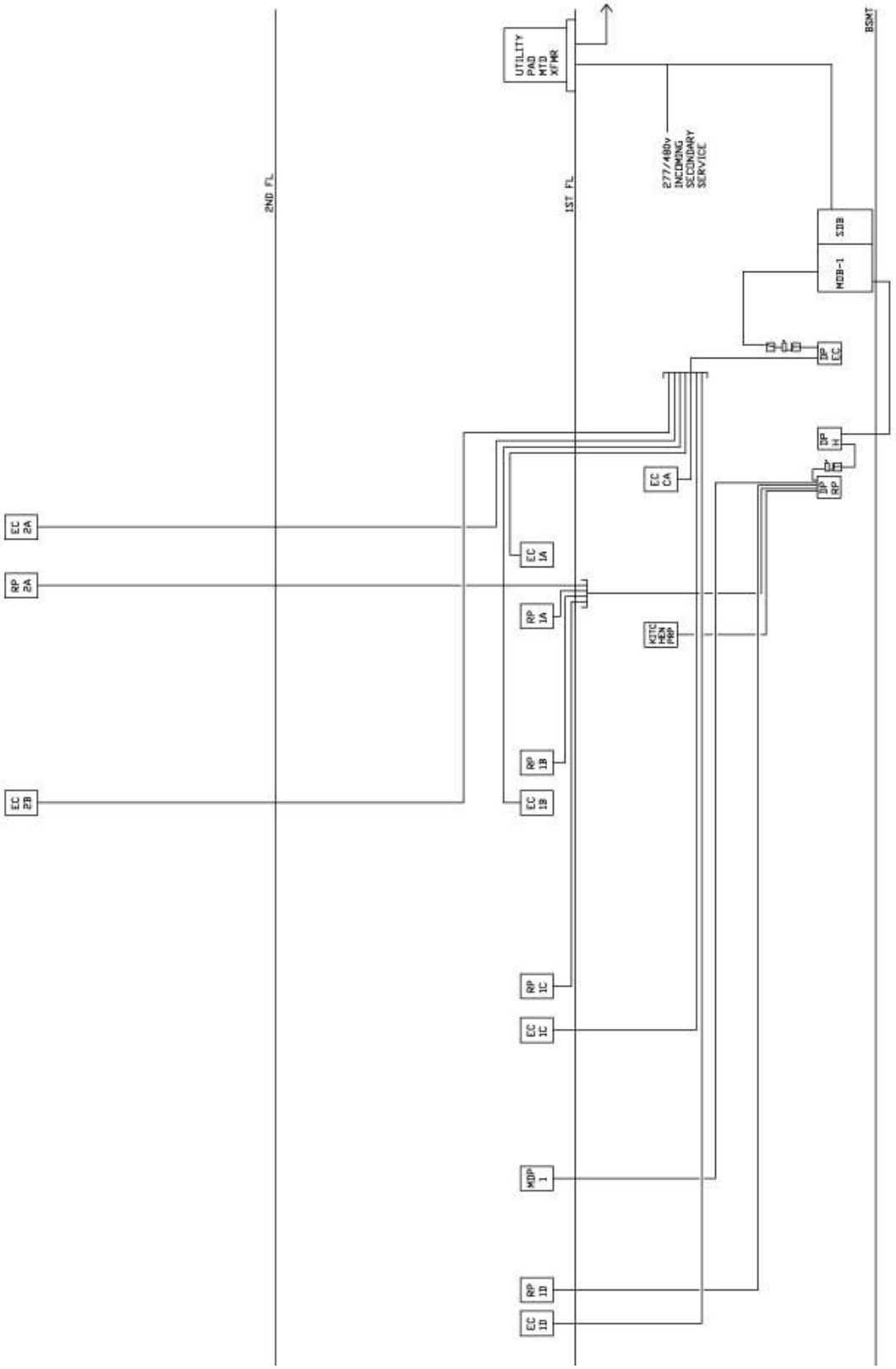
Solution Overview:

Many of the feeders running from the distribution panels to each panelboard are fairly long in length. Reducing the size of these feeders may save money on the electrical system. To allow the reduction of conductors, conduit, and circuit breakers, the existing transformer that serves the each distribution panel will be removed. Instead smaller transformers will be added directly before each panelboard. The cost of the new feeders will be less since smaller wires and conduit will be used, each circuit breaker will also be smaller and therefore less costly. However, the total savings will only be substantial if the money saved on the feeders and circuit breakers outweighs the increased price of additional transformers.

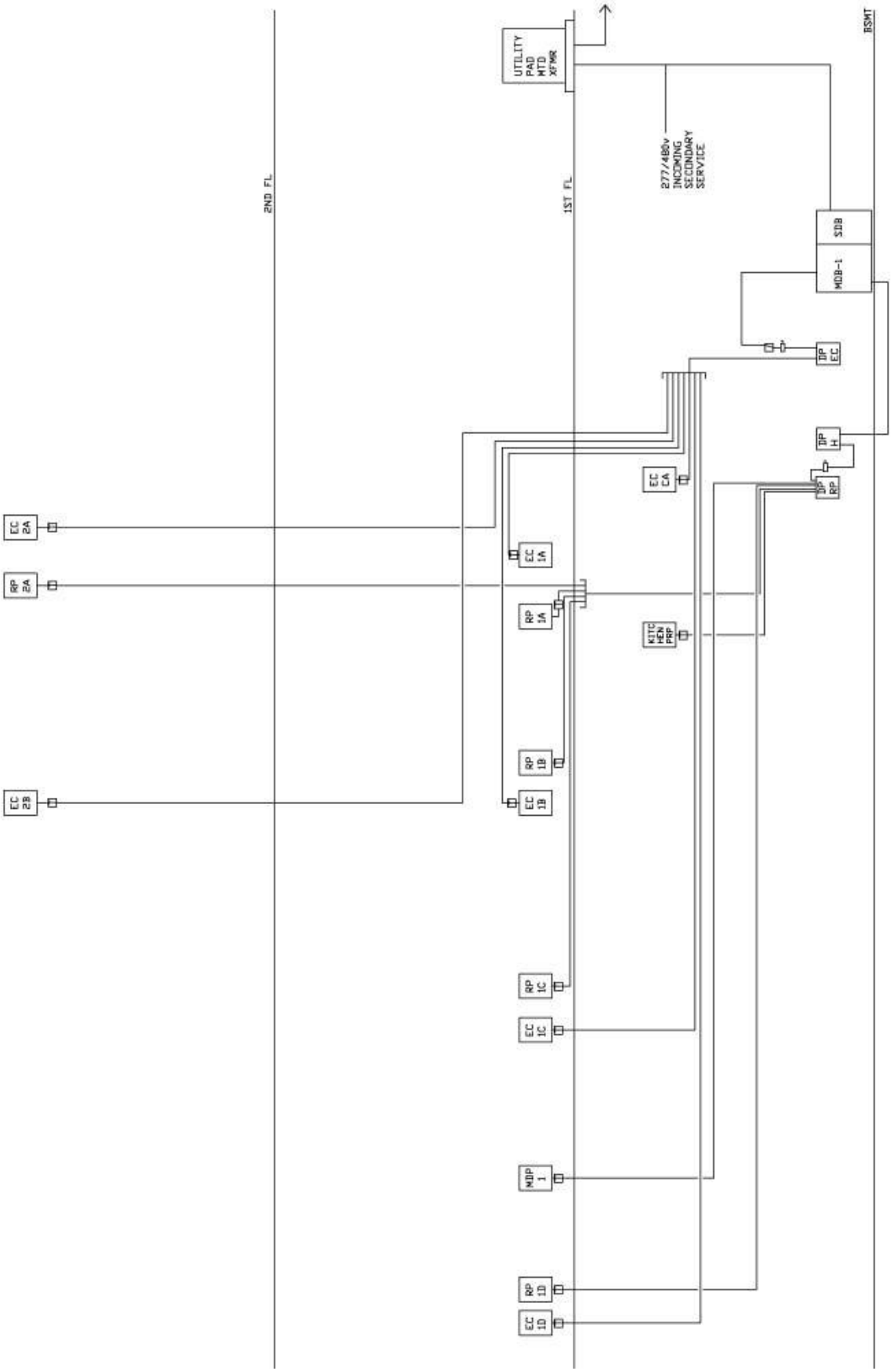
Design Goals:

The main goal of this redesign is to see if money can be saved by using several smaller transformers and smaller conductors, conduits and circuit breakers. The cost of the old system and new system will be compared at the end of the design in the construction management breadth to determine if this would be a feasible alternative to the current electrical system.

Riser Diagram for Existing System



Riser Diagram for Redesign



Existing Load

The electrical drawings that are available for the Franklin Care Center are not complete, so additional work must be done to determine the load on each of the panelboards. The drawings do not show circuiting from equipment and loads to each panelboard, so the load needs to be determined by using the wire size that was shown on the electrical drawings. It is typical that a feeder is sized for 125% of the actual peak continuous load that it carries. It must be confirmed that this was how the feeders were designed in the Franklin Care Center.

Five panelboards serve the receptacle loads in the Franklin Care Center. Each panel board serves 148 receptacles via 4#2 THWN 70degree C conductors in 1 ¼ " conduit. According to the National Electric Code, each general use duplex receptacle shall have a load of 180VA, however according to a practicing electrical engineer they typically assume a higher load of 200 watts each. The feeder must also be de-rated by 80% for continuous load, so the actual load must be multiplied by 125% to get the design load for the feeder. In my design it will be assumed that each duplex receptacle is 200 watts, the feeder is de-rated by 80%, and the power factor for the load is .90.

Load per duplex receptacle: 200 Watts / .9 = 222.22VA
Load per receptacle panelboard: 222.22 VA * 148 receptacles = 32889VA
Ampere rating: 32889VA / (208V* 1.73) = 91.29 A
Continuous load multiplier: 91.29 A * 125% = 114A

Using my assumptions, the feeders would be 4#2, which is what was actually used. This shows that the assumption that the feeder carries 125% of the typical load is valid and can be used to calculate the actual load of each panelboard and use that load to resize each feeder.

DP-RP

The following table is a summary of the equipment used in the existing electrical system to connect the receptacle distribution board to each receptacle panelboard.

Existing From DP-RP					
Panelboard	**Feeder length in feet**	**Conductor**	**Conduit**	**Circuit Breaker**	**Transformer Size**
Kitchen	220	4#2, 1#2 ground	1 1/4"	100A	n/a
RP-1A	316	4#2, 1#2 ground	1 1/4"	100A	n/a
RP-1B	542	4#2, 1#2 ground	1 1/4"	100A	n/a
RP-1C	954	4#2, 1#2 ground	1 1/4"	100A	n/a
RP-1D	888	4#2, 1#2 ground	1 1/4"	100A	n/a
RP-2A	868	4#2, 1#2 ground	1 1/4"	100A	n/a
MDP-1	327	4#3/0, 1#3/0 ground	2"	200A	n/a
					300KVA

Re-sized feeders

For Kitchen panel, RP-1A, RP-1B, RP-1C, RP-1D, RP-2A

The loads on these panelboards were determined by assuming an equal number of receptacles on each panelboard and a load of 200w/receptacle with a power factor of 0.9.

Load per panelboard: 222.22 VA * 148 receptacles = 32889VA
Ampere rating: 32889VA / (480V * 1.73) = 39.5A
Continuous load multiplier = 39.5 A * 125% = 49.45A
*Use 4#8 with 1#8 ground in ¾" conduit with 50A circuit breaker for each panelboard

For MDP-1

The load on the MDP was determined by assuming that the existing feeder is sized for 125% of the actual load.

Load per panelboard: 200A / 1.25 = 160 A actual load * 208V * 1.73 = 57642.65VA
Ampere rating: 57642.65 VA / (480V * 1.73) = 69.33A
Continuous load multiplier: 69.33A * 125% = 86.67A

*Use 4#3 with 1#3 ground in 1 ¼" conduit with 90A circuit breaker

Transformer sizing

Assumed size of current transformer

32889VA * 6 panels = 197334VA + 57642.65VA = 254.98KVA
Transformer size = 300 KVA

For Kitchen panel, RP-1A, RP-1B, RP-1C, RP-1D, RP-2A

32.889KVA
Transformers sizes = 45 KVA

For MDP-1

57.6427KVA
Transformer size = 75 KVA

Transformer Locations

The existing step down transformer for the receptacle distribution is currently located in the basement. For the redesign each step down transformer will need to be located near the panel board that it is serving. This requires more space for transformers, and space in closets of utility rooms where the transformers can be located.

Kitchen panel transformer:
Will be located in the cellar adjacent to the kitchen area in the paper room.
RP-1A transformer:
Will be located in the electrical closet on the first floor where the panels are located.
RP-1B transformer:
Will be located on the first floor in the closet where panels RP-1B and LP-1B are located.
RP-1C transformer:
Will be located on the first floor in the chart room where panels RP-1C is located.
RP-1D transformer:
Will be located on the first floor in the closet where panels RP-1D, EC-1D, EES-1D, LP-B, and PP-1 are located.
MDP-1 transformer:
Will be located on the first floor in the mechanical room where the MDP, EC-101, EES-1F, and ELS-2D1 panels are located.
RP-2A transformer:

Will be located on the second floor in the closet where the panels RP-2A, LP-2, EC-2A, ELS-2A, and EES-2A are located.

Summary of Redesign

The following table summarizes the equipment that will be used in the redesign to connect the RP distribution board to each RP panelboard.

Redesign From DP-RP					
Panelboard	**Feeder length in feet**	**Conductor**	**Conduit**	**Circuit Breaker**	**Transformer Size**
Kitchen	220	4#8, 1#8 ground	3/4"	40A	45 KVA
RP-1A	316	4#8, 1#8 ground	3/4"	40A	45 KVA
RP-1B	542	4#8, 1#8 ground	3/4"	40A	45 KVA
RP-1C	954	4#8, 1#8 ground	3/4"	40A	45 KVA
RP-1D	888	4#8, 1#8 ground	3/4"	40A	45 KVA
RP-2A	868	4#8, 1#8 ground	3/4"	40A	45 KVA
MDP-1	327	4#3, 1#3 ground	1 1/4"	70A	75 KVA

DP-EC

The following table is a summary of the equipment used in the existing electrical system to connect the emergency critical distribution board to each emergency critical panelboard.

Existing From DP-EC					
Panelboard	**Feeder length in feet**	**Conductor**	**Conduit**	**Circuit Breaker**	**Transformer Size**
EC-CA	395	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-1A	224	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-1B	542	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-1C	934	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-1D	870	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-1D1	758	4#6, 1#6 ground, 1#6ig	1 1/2"	70A	n/a
EC-2A	417	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
EC-2B	546	4#2, 1#2 ground, 1#2ig	1 1/2"	100A	n/a
					300 KVA

Re-sized feeders

For EC-CA, EC-1A, EC-1B, EC-1C, EC-1D, EC-2A, EC-2B

The load on these panelboards was determined by assuming that the existing feeder is sized for 125% of the actual load.

Load per panelboard: 115A/125% = 92A actual load * 208 *1.73= 33144.5 VA
Ampere rating: 33144.5VA / (480 * 1.73) = 39.9 A
Continuous multiplier: 39.9A * 125% = 49.8A
* Use 4#8, 1#8 ground and 1#8 IG in

For EC-1D1

The load on this panelboard was determined by assuming that the existing feeder is sized for 125% of the actual load.

Load for panelboard: 65A / 125% = 52A actual load * 208 * 1.73 = 18733.86 VA
Ampere rating: 18733.86 VA / (480 * 1.73) = 22.53 A
Continuous multiplier: 22.53 A * 125% = 28.17A
* Use 4#10, 1#10 ground, 1#10 IG in

Transformer sizing

Assumed size of current transformer:
33144.5VA * 7 panels = 232011.5 VA + 18733.86 VA = 250.75 KVA
Transformer size = 300 KVA

For panels EC-CA, EC-1A, EC-1B, EC-1C, EC-1D, EC-2A, EC-2B
33144.5 VA
Transformer size = 45 KVA

For panel EC-1D1
18733.86 VA
Transformer size = 30 KVA

Transformer Locations
The existing step down transformer for the emergency critical distribution panel is currently located in the basement. For the redesign each step down transformer will need to be located near the panel board that it is lowering the voltage for. This requires more space for transformers, and space in closets of utility rooms where the transformers can be located.

EC-CA:
The transformer will be located near the wall adjacent to the exam room where panels ELS-CA, EC-CA and EES-CA are located.
EC-1A:
Will be located in the electrical closet on the first floor where the panels RP-1A, EC-1A, ELS-1A, and LP are located.
EC-1B:
The transformer will be located on the first floor in the office where panels EC-1B, EES-1B, ELS-1B are located.
EC-1C:
The transformer will be located on the first floor in the soiled linen room where panels EC-1C, EES-1C, and ELS-1C are located.
EC-1D:

Will be located on the first floor in the closet where panels RP-1D, EC-1D, EES-1D, LP-B, and PP-1 are located

EC-1D1:

Will be located on the fist floor in mechanical room where panels EC-1D1, EES-1F, ELS1D1.

EC-2A:

Will be located on the second floor in the closet where the panels RP-2A, LP-2, EC-2A, ELS-2A, and EES-2A are located.

EC-2B:

Will be located on the second floor in the closet where panels EES-2B, ELS-2B, and EC-2B are located.

Distribution board sizing

The existing EC distribution board is 208/120, after the redesign the distribution board will be 480/208. Since this board will be at a different voltage and being served directly from the MDB it must be resized. DP-RP did not need to be resized since it is served from another distribution board.

The existing DP-EC was 208/120 V, 3 phase, 4 wire 800A.
The redesigned DP-EC will be 480/277 V, 3 phase, 4wire, 400 A

Summary of Redesign

The following table summarizes the equipment that will be used in the redesign to connect the EC distribution board to each EC panelboard.

Redesign For DP-EC					
Panelboard	Feeder length in feet	Conductor	Conduit	Circuit Breaker	Transformer Size
EC-CA	395	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-1A	224	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-1B	542	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-1C	934	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-1D	870	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-1D1	758	4#10, 1#10 ground, 1#10ig	3/4"	30A	30 KVA
EC-2A	417	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA
EC-2B	546	4#8, 1#8 ground, 1#8ig	1"	40A	45 KVA

Conclusions

Placing the transformers directly before each panel rather than using only one for the entire distribution board allows all feeders to be smaller. There will be seven smaller transformers as opposed to one larger transformer. Using smaller feeders will save space in the ceiling plenum; however room near each panelboard will be needed to allow each transformer to be placed there. There is enough room to fit a transformer in each of these spaces, so no architectural redesign will be necessary. An in-depth cost analysis of both systems can be found in the Construction Management Breadth.