Dec 1702A
Final Report
Algona Municipal Utilities Distribution System Design

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Motivation

Algona is a growing city of 5560 people in the county seat of Kossuth County, Iowa. Our client, Algona municipal utility, concentrates on providing high reliability electricity, gas and water to Algona customers. Based on this goal, Algona municipal utility worked with a team of students to improve the current distribution system for the second largest customer in the Algona. Comparing with the current system, the new design should have some characteristics like flexibility, safety, high reliability, low budgets, etc. Algona municipal utility provided the whole town distribution system map, one year Advanced Metering Infrastructure (AMI) data of the customer, current transformer nameplate and DeWild Grant Reckert (DGR) engineering draft Milsoft model [14] for students.

Project Statement

Our customer is a large industrial customer that provides a lot of job positions for the Algona community. That means it's important to provide highly reliable power supply continuously. Based on a visit to Algona and follow-up communication, the old overhead line and vegetation problem caused frequent outages and expensive maintenance costs to the utility. A review of 2016-2017 customer AMI data, we learned that the north meter had 8 outages events with roughly total 15 hours and the south meter had 17 outages events with roughly total 35 hours, Appendix Figure 1. As an industrial company, stable power supply is required to ensure profitable operations. Our industrial customer has a future plan to double the current load within the next five years. How to keep a stable power supply for the extended plant is the significant question for this project. The project team also needed to provide an improved route to avoid a pond, farmland, railroad and C bus. In addition, some basic technology requirements were also considered, like keeping two feeders from two substations, using the correct size of conductor and vegetation management problems on the feeders. The team used the DGR engineering draft Algona model as the basic model to test the new design. DGR, a professional engineering company that built the distribution model, worked with the Algona municipal utility to build the Milsoft model before. The team was given permission to use the Algona whole town distribution model. The advantage of the basic model is to help Algona municipal utility to plan its future upgrade.

Deliverables

1) Final report about whole project including standard, simulation mode, equipment specifications.
2) Algona town Milsoft model with new design.
3) Transformer cost and parameter.
4) Conduit cost and parameter.
5) Cable cost and parameter.

Design Requirement

Based on the suggestions from the Algona municipal utility and the physical limitations on routing (vegetation, streams, roadways and railroad crossings), we choose one of three design routes as our final design route. Three draft design are shown in the Appendix, Figures 8-10. The final design route uses entirely underground cable to build the distribution system for our customer. Two transformers will be added at the customer's plant to reduce the main line voltage. Two switches will be added to create a close-loop distribution system to meet the load requirement. The new underground cable will follow the road so as to shorten the route and thus decrease the installation fee of cable. Using the measurements along the road it is easy to estimate the impedance length.

The final goal of Algona municipal utility is to bury all distribution line in the future. Our final design chose underground cable to prevent the future reconstruction fee and decrease outages for customer. The cable follows the road in order to provide a better location for the primary riser, shown in Appendix Figure 14 , to connect the current overhead line and new underground cable, for ease of accessibility and expandability.

Since the team is developing a hypothetical scenario, it is necessary to consider the load change and physical size change. It is difficult to forecast the industrial load for 5 years load forecasting with limited historical data. Even with the historical data supplied by Algona, 5 years load forecasting will have a large error with the real data. Based on the current load data analysis, we find the maximum load time of two meters is different. Appendix Figures 1-4 shows the one year load graph , average daily load graph of two meters, and average daily power factor graph of two meters. About the power factor, we can find the average power factor of north meter is about 0.83 and 0.89 for south meter. Based on the 0.9 power factor standard, both of two current feeders are poor power factor status. We had a communication with Algona about power factor, they will require the plant to arrive 0.9 power factor in the near future to improve the power efficiency. In our design, we just set constant power factor as 0.9 to decrease the difference between simulation load with future real load. And combine with the future double load plan with Industrial consumer, we would double 15-minute maximum non coincident demand [15] to as the forecast load demand in our design.

Design Principle

In our design, even though we have some different view with DGR design model about Algona distribution system, we still follow the DGR model to build our new routine in model I. But we also provide our own idea about model in model II. In our own view, we trust the actual plant load should be larger than data of DGR model.

Based on the current DGR Algona distribution system model, EB5 is primary feeder, Feeder 1 is secondary feeder. The switch of feeder 1 is normally open as emergency feeder. EB5 supports the whole plant energy with about 1800 KVA. The Appendix Figure 6 shows the original model report. Based on the Algona distribution system map, we build our new design. As illustrated in Appendix ?? figure 8-10, we were exploring 3 geographic draft design. Upon discussions and evaluations, we finally choose the last one as geographic route design -- mostly based on the outcomes of the communications with Algona Municipal Utilities. Once the geography design has been agreed upon, we proceeded with two alternative models for the use of data: DGR original load data and AMI load data.

We think about the load problem in DGR model during the analysis 2016-2017 AMI data of plant. From the analysis of 2016-2017 plant AMI data, we find the total reality load of plant should be larger than the DGR model and both meters have continuous data. Based on Appendix Figure 3, the max kw demand of 2016-2017 plant is about 2400 KW. So we build our design with this load data in the model II.

Transformer

In our design, we keep two feeder design. That means we will need a new transformer for each feeder to reduce main line voltage for our customer at the plant. Algona provided the existing transformer nameplate information. Based on the current transformer nameplate, we know it is a three phase transformer with the cooling type, input and output voltage, percentage of impedance and the frequency of the system.. In choosing our transformer we used the same parameter as the existing transformer because of limit of data.

Then, based on a three phase transformer, we use formula [4] $\frac{load\ voltage * AMPS * 1.732}{1000} = KVA$ to find future transformer KVA rating. For our two models, we use two different KVA rating. One is that main transformer is 4200 KVA and secondary transformer is 1500KVA with one normally open switch and one normal close switch, and another one is that the main transformer is 4000 KVA and the secondary transformer is 1500KVA with both normally closed switch. For the percentage of impedance, we want a range from 5% to 7% because higher impedance means higher voltage drop and also based on the current transformer is 5.75%. Frequency is still very important parameter because different frequency will change voltage, current and core loss. The last element is the cooling type. The cooling type of the current transformer is OA of liquid cooled which means oil-immersed, self-cooled with standard ANSI/IEEE C57.12.00-2000 [5]. Cooling type is important because good cooling type helps transformer to reduce the heat risk which can reduce the lifespan of transformer. A longer lifespan is an important factor to estimate whether transformer is a high efficiency transformer. Also, we known the present transformer has high heat with unknown reason from Algona Municipal Utilities. So for our transformer choosing, we want to find a transformer with OA/FA which means same with OA with addition of fans that can help transformer forced air-cool. Addition fans can reduce the heat impact with current unknown reason.

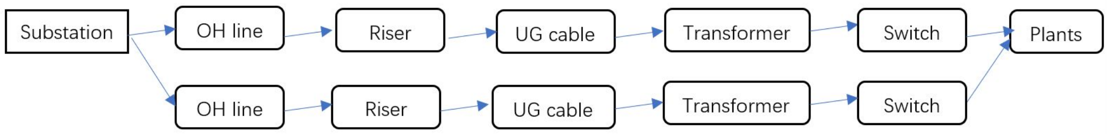
In conclusion, we tried to find a 60Hz-three phase transformer that at least meet KVA requirements, impedance, and cooling type. The price of transformer will be post on the later report. In order to properly specify a high efficiency transformer, harmonics data or K factor data should be known. That will help to pick a low loss and longer lifespan transformer [6]. Currently, we cannot provide relative result for that. But we recommend Algona municipal Utilities to collect these data for the future.

Cable

Based on the ICEA S-95-658-1999 Standard we will use 220 mils insulation thickness which is 133% insulation level to choose our underground cable [7]. We found that there are many aspects that can impact the cable current capacity, including conductor size and the choice of materials . Even though copper is a better conductor, we still prefer Aluminum because Al is a cheaper price material that can satisfy our requirement. In choosing cable, we wanted our cable to be all EPR, Ethylene propylene rubber--a type of synthetic elastomer, system[12]. Also there are two types of neutral we need to think about--Full neutral and ⅓ neutral. Compared with ⅓ neutral, full neutral can allow higher current flow with higher cost. For our secondary feeder, ⅓ neutral cable should be enough.

Simulations and Modeling

As part of the developments and, in particular, evaluations we determined that the DGR load data is different from our AMI analysis data. This prompted us to design two distinct models with same geographical route design.



Model I

For this model, it is based on the DGR load data which only have data in the main feeder. We choose 4000 KVA transformer in our main feeder and 1500KVA transformer in our secondary feeder. The switch in main feeder will normally closed and secondary switch will normally open. In this design, we figure out each transformer in each feeder in original model and we just double the main feeder transformer. Also, those two new feeders will only service this plant and no other consumers.

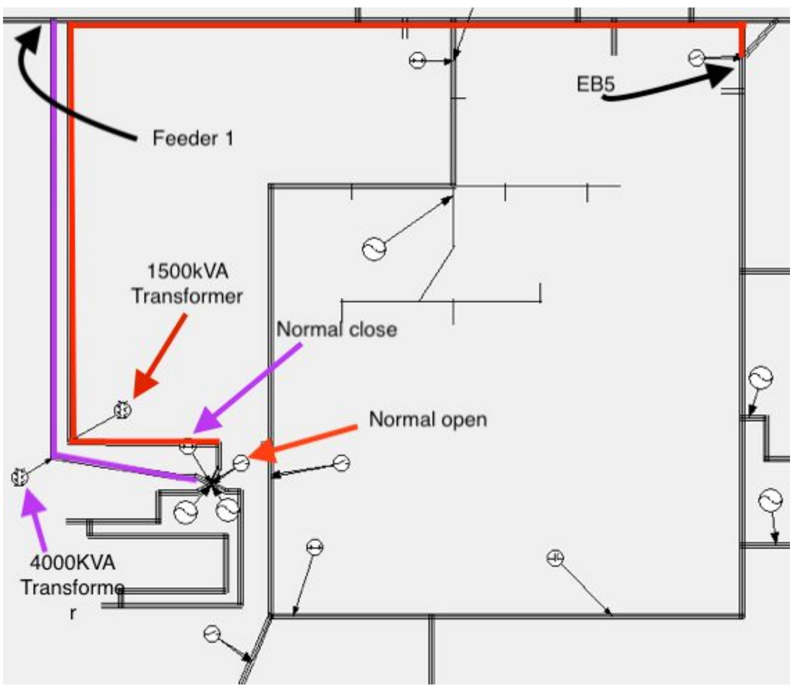


Figure 1 Milsoft Model I

Model II

For this design, the load should be larger than DGR setting. We are using AMI data to find the maximum KVA data in each feeder. And the secondary feeder can not add too much load because it will cause voltage below our standard(±5%) We decide to add more load to our primary feeder and we calculate the future tota load of plant will up to 4800 KVA, the primary feeder is 4000 KVA and secondary feeder is 1333 KVA. We want to our feeder has some feasible and we will using 4200 KVA transformer in our main feeder and 1500KVA transformer in our secondary feeder. in addition, two switches are normally close.

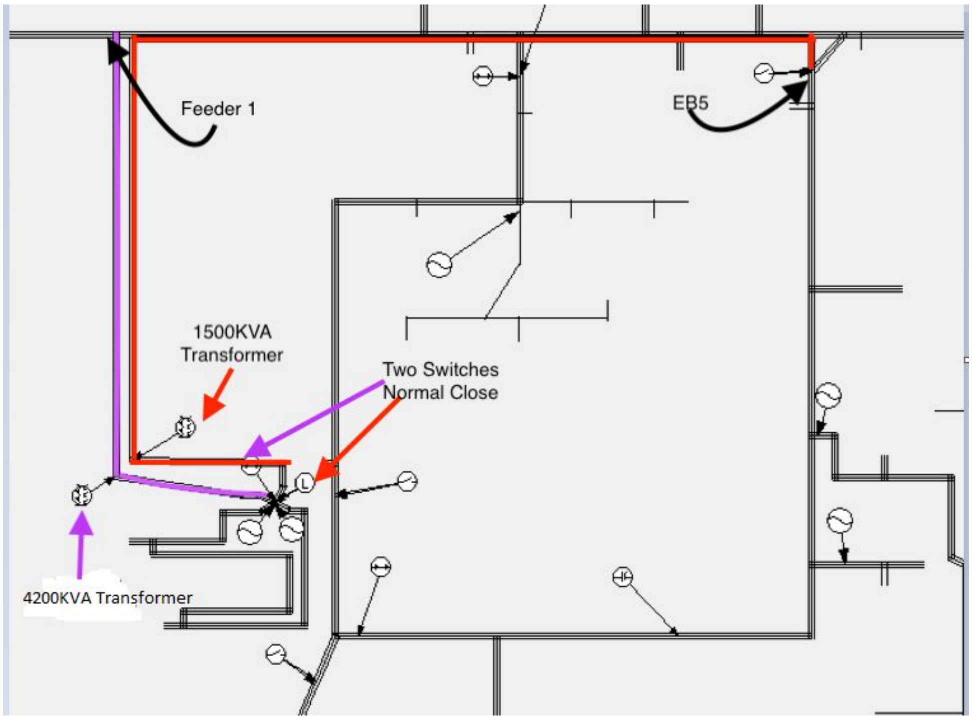


Figure 2 Milsoft Model II

Difference:

Two design have the same geology design and the only difference is one use DGR data and the another one use AMI data. The difference data that we will use different transformer for each feeder.

Standards

The project used the specifications provided in the United States Department of Agriculture Rural Utility Service (RUS) as the construction standards [1]. RUS are the standard for all public power utilities and Algona municipal utility hasn't developed its own construction standard. The Pad Mounted Transformer construction figure is shown in the Appendix Figure 14 . We will use American National Standards Institute (ANSI) C84 standard [2] to test our design that the service voltage should be

120±5%(Figure 3). The DGR model is using 120 base voltage. The lowest base voltage is 114V and the highest base voltage is 126V. We will convert the voltage to 120V base and compare with standard.

Table 1. National Steady State Voltage Regulation Standards

Nominal	Service	Utilization	Nameplate	NEMA
Standard	-5%, +%5	-13%, +6%	Motor	-10%, +10%
120	114 - 126	104.4 - 127.2	115	103.5 - 126.5
208	197.6 - 218.4	181 - 220.5	200	180 - 220
240	228 - 252	208.9 - 254.4	230	207 - 253
277	263.2 - 290.9	241 - 293.6		
480	456 - 504	417.6 - 508.8	460	414 - 506
	bandwidth 10%	bandwidth 19%		bandwidth 20%

Figure 3

In addition, we need to choose the cable for our designs and we will using NEMA and ICEA standards such as ICEA S-95-658-1999 Standard [3] for Non Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy with Figure 4 .

Voltage Rating (kV)	Insulation Level (%)	Typical Insulation Thickness	
		mm	mils
5	100	2.29	90
	133	2.92	115
	173	3.56	140
8	100	2.92	115
	133	3.56	140
	173	4.45	175
15	100	4.45	175
	133	5.59	220
	173	6.6	260
25	100	6.6	260
	133	8.13	320
	173	10.67	420
35	100	8.76	345
	133	10.67	420
	173	14.73	580

Table 1: Insulation Thicknesses for Insulation Levels

Figure 4

Design Analysis

Model	Original model	Model I	Model II
primary feeder	EB5 4/0AL 220EPR 1/3-90	Feeder 1 4/0AL 220EPR FUL 105 ...	Feeder 1 350AL 220EPR 1/3-90 ...
Primary	326A	350 A	408A

carrying current capacity			
Secondary feeder	Feeder 1 4/0AL 220EPR 1/3-90	EB5 4/0AL 220EPR 1/3-90	EB5 4/0AL 220EPR 1/3-90
Secondary carrying current capacity	326A	326A	326A
3 Phase	Y	Y	Y
Balanced load	Y	Y	Y
Operate Switch	EB5 normal close & Feeder 1 normal open	Feeder 1 normal close & EB5 normal open	Feeder 1 & EB5 normal close
Primary feeder load	1638KW	3276KW	3600KW
Secondary feeder load	0	0	1200KW
Primary Transformer Capacity	2000KVA	4000KVA	4200KVA
Secondary Transformer Capacity	1500KVA	1500KVA	1500KVA
Power Factor	0.889 & 0.831	0.9 & 0.9	0.9 & 0.9
Feeder type	OH, pole	UG, conduit	UG, conduit

Cost

There are two main parts we need to think about for our cost forecast--transformer and cables with conduit pipe.

For the transformer part, we received ABB Inc price about $17/KVA for transformer.

Model I

- Primary Transformer: 4000 KVA, three phase, 60 Hz, percentage of impedance from 5% to 7%, OA/FA, Around total $68000.

- Secondary Transformer 2: 1500KVA, three phase, 60 Hz, percentage of impedance from 5% to 7%, OA/FA, Around total $25500.

Model II

- Primary Transformer: 4200 KVA, three phase, 60 Hz, percentage of impedance from 5% to 7%, OA/FA, Around total $71400.
- Secondary Transformer: 1500KVA, three phase, 60 Hz, percentage of impedance from 5% to 7%, OA/FA, Around total $25500.

For the cables and conduit pipe,we prefer use Aluminum because Copper has higher cost. For example: For 4/0, 220 mils, EPR. The price of Aluminum is $2.9/ft and the price of Copper is $6.12/ft [13].

For the first model, we compared three different cables:

1. 4/0, 220 mils, EPR, Full neutral (Special Order)
2. 4/0, 260 mils, EPR, Full neutral (Special Order)
3. 4/0, 320 mils, EPR, Full neutral (Special Order)
4. 4/0, 220 mils, EPR, ⅓ neutral ($4.63/ft)

For the primary feeder, we chose option 1 because it has the thinnest thickness which means has lowest cost. For the secondary feeder, the fourth cable with lower maximum current should be enough. The difference between 1,2 and 3 is the thickness of the cable. Different thickness represents different insulation level. 220 mils has 133% insulation which is already suitable for underground cable [7] and it has the lowest cost because of its thinnest thickness. For 4/0, 220 mils, EPR, ⅓ neutral, we have two different products from the Okonite, a Electrical Wire and Cable Manufacturer. Okonite 160-23-3081 and 162-23-3081 are the work cable for our model [9]. The difference of these two is that 160-23-3081 does not have water damage protect and 162-23-3081 has. Because we don't know the sponsor require about the water damage protect, we still pick the lower cost cable in our total cost. But we still provide the cable with water damage protect for consider. And because we have limit authority to find all production price, like 4/0, 220 mils, EPR, full neutral cable, we still provide production links for our customer.

For the second design, we also have couple choices:

1. 350 220 mils, EPR, ⅓ neutral ($6.04/ft)
2. 350 420 mils, EPR, ⅓ neutral (Special Order)
3. 500 175 mils, EPR, ⅓ neutral ($7.45/ft)

4. 500 220 mils, EPR, ⅓ neutral (Special Order)

We use Okonite Company as the main company for providing the cable (http://okonite.com/Product_Catalog) and these cable prices are provided by Wesco of Des Moines.

Based on Algona requirements we choose conduit to bury our underground cable, so we considered the price of conduit pipe. We find different types of conduit pipe made with different materials, such as EMT, LMC, GRC by steel , Sch 40 PVC pipe and Sch 13.8 HDPE [8]. Our customer prefer Sch 40 PVC or Sch 13.8 HDPE. So we finally choose Sch40 PVC pipe because its price is easy to find and there are some difference prices so that we can compare and decide.

For the impedance length, we separate total impedance length for 4 parts :

Line A: The distance starts in a blue top warehouse near Kemco Tire Inc and finishes at the main road--220th St. It is 69 ft.

Line B: The distance starts from the finish point in Line A and finishes to the point which is the nearest to 220th St from our target. It is around 1841 ft.

Line C: The distance starts at the finish point from Line B to our target. It is around 991.52 ft.

Line D: The distance starts at the finish point from Line B to our target. It is around 981.74 ft

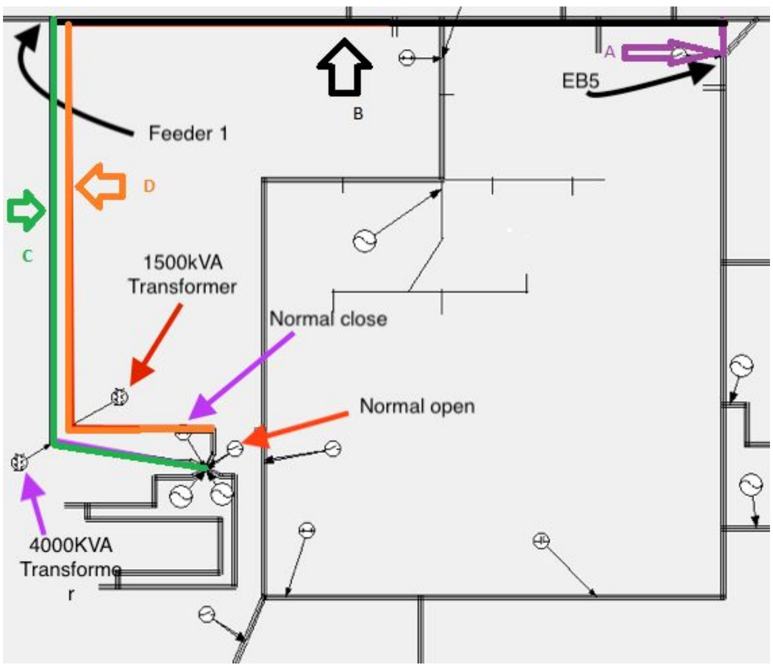


Figure 5 Impedance length

For the conduit pipeline, we find three different pipeline quotes from online:

1. http://www.usplastic.com

   (United States Plastic Corp $1.89/ft)

2. https://www.grainger.com

   (Grainger $1.84/ft)

3. https://www.pvcpipesupplies.com

   (PVC Pipe Supplies $1.15/ft)

Compared with these three different productions, we find they have slightly different weight, almost same maximum temperature and maximum pressure . We prefer PVC Pipe Supplies productions because it has the lowest cost.

Interest rate and Inflation rate

As a future 5 year project, we need to find interest rate and inflation rate to calculate the real purchase power [10]. Although we don't have the investment cost because of transformer price and cable price, we still can provide the interest rate and inflation rate for our customer to help them find the time of cover the investment cost. We find forecast interest rate and inflation rate until year of 2020. The current October to December of 2017) inflation rate in US is 2% and current interest rate in US is 1.5%. The forecast (Year of 2020) inflation rate in US is 2.5% and forecast interest rate is 3% [10]. Here are the relative formula of Interest cost and Inflation rate:

Interest Cost= total cost * 1.5% * 5 [17]

Current Year Index= $\frac{current\ year\ price}{Base\ year\ price}$ *100% [16]

Total Cost

Finally, we summary the total cost of transformer and underground cable with conduit pipe. Because we can not know the price of transformer we need and some types of cable, we will use "Y" to represent the cost of the cable of 4/0, 220 miles, EPR, Full Neutral. Here is the final total cost table:

	Model I ($)	Model II ($)
Transformer	93,500	96,900
Cable	40,305+Y	58,389
Conduit Pipe	5,824.89	5,824.89
Total	/	161,113.89

*This total cost is the maximum cost. That means it possible uses present transformers to decrease part of cost.

Conclusion

In this project, we designed three different geographic designs and we picked one. Then we designed two model based on different load data, one is from DGR model and one is from 2016-2017 customer AMI data, with constant 0.9 power factor. In addition, we checked each feeder current and figure out maximum current capability. Then, we were using NEMA and ICEA standards such as ICEA S-95-658-1999 Standard [3] for Non Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy to choose our distribution cable. We also ran our model to check the voltage drop and it should satisfy American National Standards Institute (ANSI) C84 standard [2]. We searched parameter about transformer and figured out the transformer size of each feeder.

For cost of cable, we recommend three types of underground cable: 1. 4/0 220 mils EPR ⅓ neutral, 2. 4/0 220 mils EPR full neutral 3. 350 175 mils EPR ⅓ neutral [9]. For the conduit, we recommend Sch 40 PVC pipe. In the cost part, we find some satisfy products and link with approximate price.

For our new transformer, we recommend three phase, 4000 or 4200 KVA , OA/FA, 60Hz, percentage of impedance is 5% to 7% and another one is three phase, 1500 KVA, OA/FA, 60 Hz, percentage of impedance is 5% to 7%. In the cost part, we find some satisfy products and link with approximate price.

Future Work

In our design, we didn't think about using present transformers because we didn't know the present condition of transformers. We only get one transformer nameplate as transformer data and know the heat problem of north 1500 KVA transformer. If Algona Municipal Utilities check the transformers status are good in the future, a new primary 1000 KVA and secondary 1500 KVA transformer should be enough for the design. The total cost would be smaller than before calculation. Based on the limit of time, we cannot simulate this possible. It should be tested in the future. And just like we mention the load problem before, we recommend Algona Municipal Utilities contacts with DGR to check model whether it presents the really situation in the future.

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Appendix I

Figure 1 2016-2017 AMI data

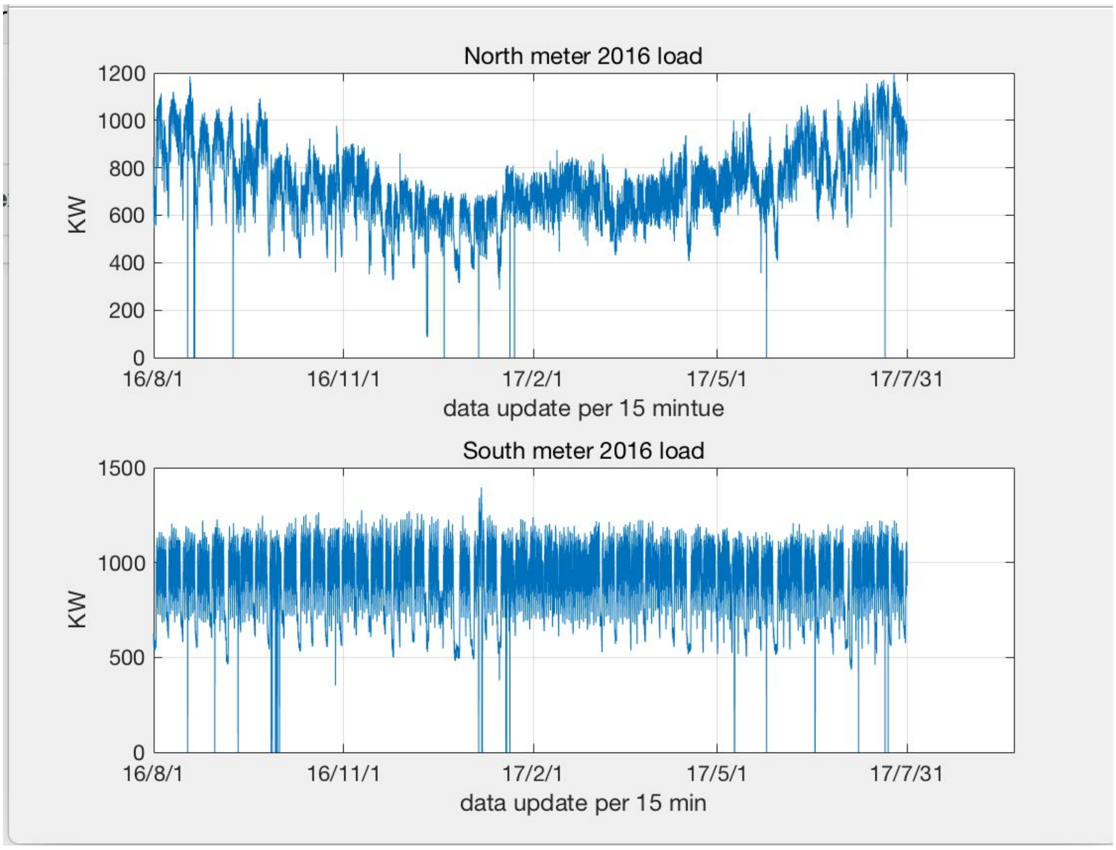


Figure 2 2016 total plant load

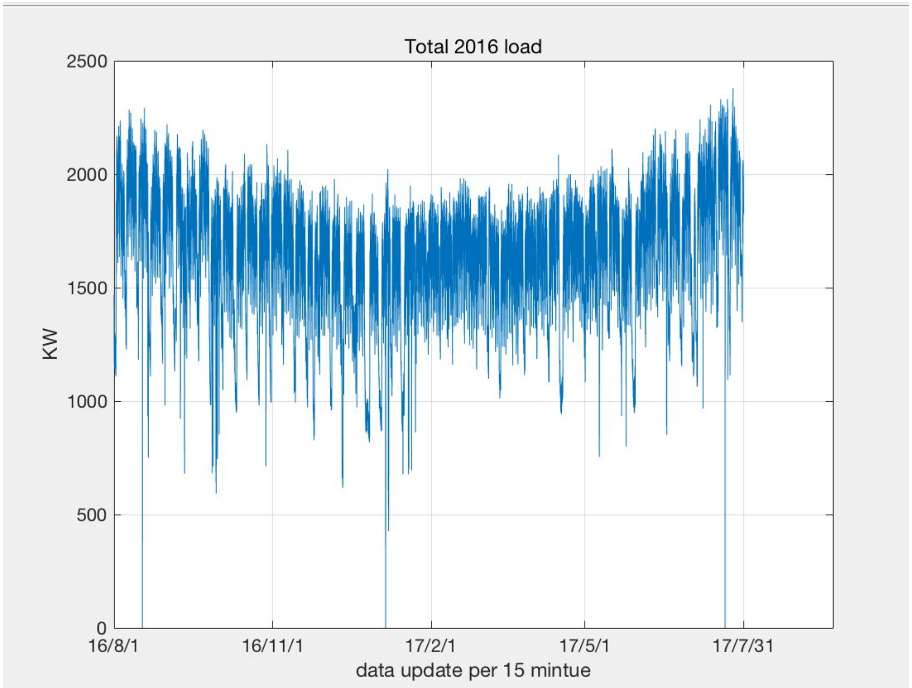


Figure 3 daily PF

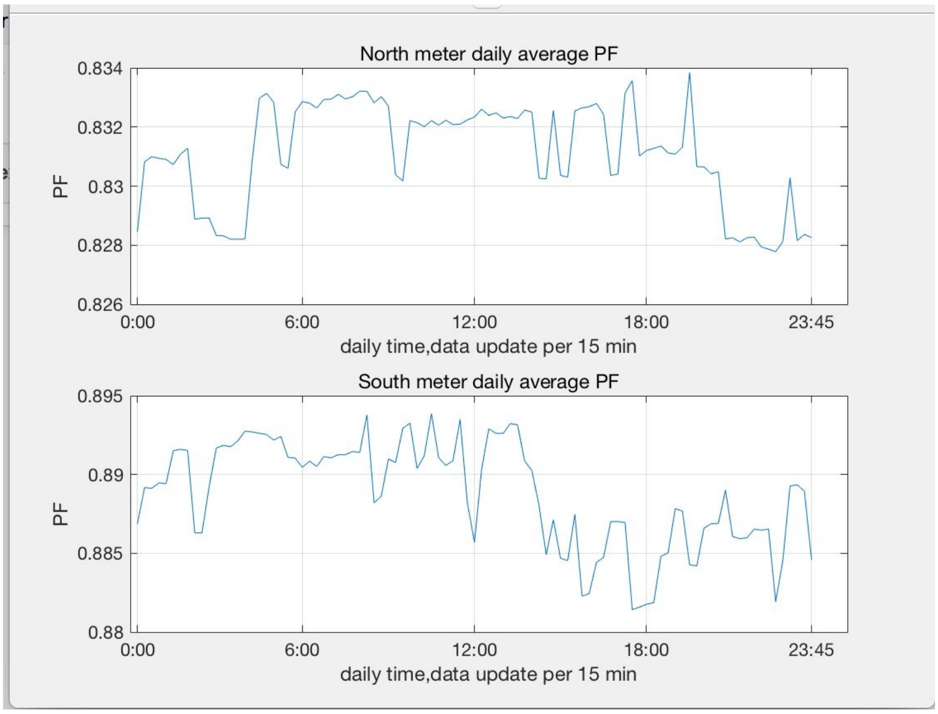


Figure 4 Daily average load

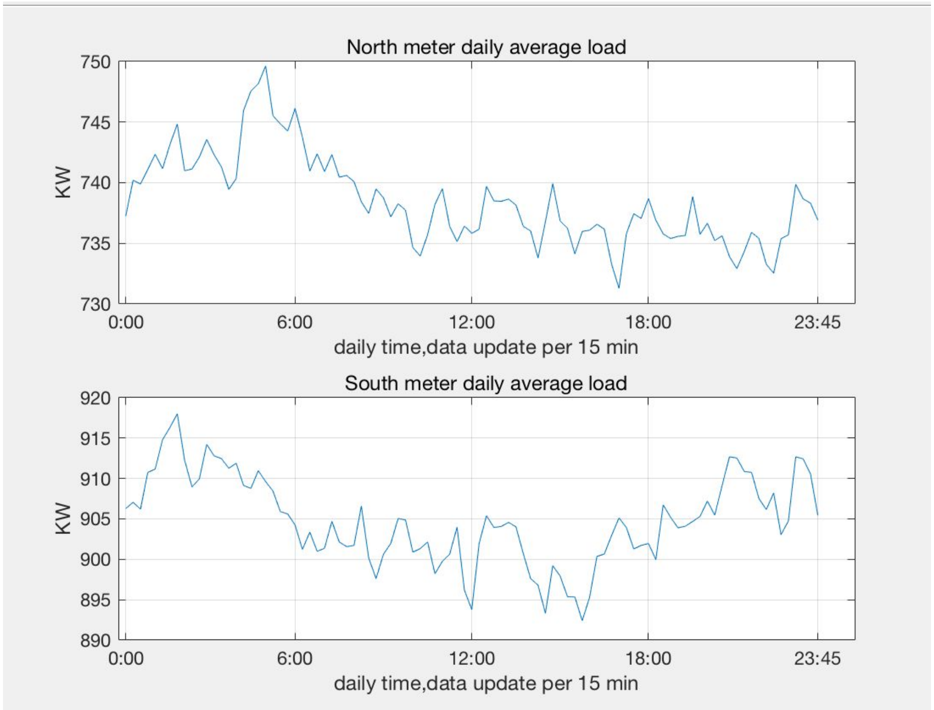


Figure 5 Original plant load report (DGR)

Units Displayed In Volts
-Base Voltage:120.0-

Element Name	Parent Name	Cnf	Type/ Conductor	Pri kV	Base Volt	Element Drop	Accum Drop	Thru Amps	% Cap	Thru KW	KVAR	% PF	kW Loss	% Loss	mi From Src	Length (mi)	Element KW	Element KVAR	Element Cons On	Element Cons Thru
P UG2178	OH2173	A	4/0AL 220E	7.77Y	117.1	0.03	2.92	78.35	24	546	270	90	0.36	0.0	1.297	0.033	0	0	0	0 P
P		B		7.89Y	118.8	0.03	1.19	77.21	24	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.03	1.58	77.46	24	546	270	90					0	0	0	0 P
P UG2179	UG2178	A	4/0AL 220E	7.77Y	117.1	0.01	2.93	78.37	24	546	270	90	0.19	0.0	1.314	0.017	0	0	0	0 P
P		B		7.89Y	118.8	0.01	1.21	77.22	24	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.01	1.59	77.48	24	546	270	90					0	0	0	0 P
P UG2180	UG2179	A	4/0AL 220E	7.77Y	117.1	0.01	2.94	78.37	24	546	270	90	0.08	0.0	1.321	0.007	0	0	0	0 P
P		B		7.89Y	118.8	0.01	1.21	77.23	24	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.01	1.60	77.48	24	546	270	90					0	0	0	0 P
P UG2181	UG2180	A	4/0AL 220E	7.77Y	117.1	0.01	2.94	78.38	24	546	270	90	0.07	0.0	1.328	0.007	0	0	0	0 P
P		B		7.89Y	118.8	0.01	1.22	77.23	24	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.01	1.60	77.49	24	546	270	90					0	0	0	0 P
P SW2182	UG2181	A	Closed	7.77Y	117.1	0.00	2.94	78.38	0	546	270	90	0.00	0.0	1.328	0.000	0	0	0	0 P
P		B		7.89Y	118.8	0.00	1.22	77.24	0	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.00	1.60	77.49	0	546	270	90					0	0	0	0 P
P SW2182-B	SW2182	A	Closed	7.77Y	117.1	0.00	2.94	78.38	0	546	270	90	0.00	0.0	1.328	0.000	0	0	0	0 P
P		B		7.89Y	118.8	0.00	1.22	77.24	0	546	270	90					0	0	0	0 P
P		C		7.86Y	118.4	0.00	1.60	77.49	0	546	270	90					0	0	0	0 P
P UG2186	EB5-UG2	A	4/0AL 220E	7.77Y	117.1	0.00	2.94	39.22	12	273	136	90	0.02	0.0	1.335	0.007	0	0	0	0 P
P		B		7.89Y	118.8	0.00	1.22	38.65	12	273	136	90					0	0	0	0 P
P		C		7.86Y	118.4	0.00	1.60	38.77	12	273	136	90					0	0	0	0 P
P UG2187	UG2186	A	4/0AL 220E	7.77Y	117.0	0.01	2.95	39.22	12	273	136	90	0.04	0.0	1.350	0.015	0	0	0	0 P
P		B		7.89Y	118.8	0.01	1.23	38.65	12	273	136	90					0	0	0	0 P
P		C		7.86Y	118.4	0.01	1.61	38.77	12	273	136	90					0	0	0	0 P
P UG2188	UG2187	A	4/0AL 220E	7.77Y	117.0	0.00	2.96	39.22	12	273	136	90	0.03	0.0	1.362	0.012	0	0	0	0 P
P		B		7.89Y	118.8	0.00	1.23	38.65	12	273	136	90					0	0	0	0 P
P		C		7.86Y	118.4	0.00	1.62	38.78	12	273	136	90					0	0	0	0 P
P UG2189	UG2188	A	4/0AL 220E	7.77Y	117.0	0.01	2.97	39.23	12	273	136	90	0.07	0.0	1.389	0.027	0	0	0	0 P
P		B		7.88Y	118.8	0.01	1.24	38.66	12	273	136	90					0	0	0	0 P
P		C		7.86Y	118.4	0.01	1.63	38.78	12	273	136	90					0	0	0	0 P
P UG2190	UG2189	A	4/0AL 220E	7.77Y	117.0	0.00	2.97	39.24	12	273	136	90	0.01	0.0	1.398	0.009	273	136	0	0 P
P		B		7.88Y	118.8	0.00	1.24	38.67	12	273	136	90					273	136	0	0 P
P		C		7.86Y	118.4	0.00	1.63	38.80	12	273	136	90					273	136	0	0 P

Figure 6 Double Plant load Data

Element Name	Parent Name	Cnf	Type/ Conductor	Pri kV	Base Volt	Element Drop	Accum Drop	Thru Amps	% Cap	Thru KW	KVAR	% PF	kW Loss	% Loss	From Src	Length (mi)	KW	KVAR	Cons On	Cons Thru
UG2180	UG2179	A	4/0AL 220E	7.80Y	117.4	0.01	2.56	156.42	48	1093	542	90	0.31	0.0	1.682	0.007	0	0	0	0
		B		7.79Y	117.4	0.01	2.61	156.49	48	1093	542	90					0	0	0	0
		C		7.79Y	117.4	0.01	2.63	156.51	48	1093	542	90					0	0	0	0
UG2181	UG2180	A	4/0AL 220E	7.80Y	117.4	0.01	2.57	156.42	48	1092	542	90	0.30	0.0	1.689	0.007	0	0	0	0
		B		7.79Y	117.4	0.01	2.62	156.49	48	1092	542	90					0	0	0	0
		C		7.79Y	117.4	0.01	2.64	156.51	48	1092	542	90					0	0	0	0
SW2182	UG2181	A	Closed	7.80Y	117.4	0.00	2.57	156.42	0	1092	542	90	0.00	0.0	1.689	0.000	0	0	0	0
		B		7.79Y	117.4	0.00	2.62	156.49	0	1092	542	90					0	0	0	0
		C		7.79Y	117.4	0.00	2.64	156.52	0	1092	542	90					0	0	0	0
SW2182-B	SW2182	A	Closed	7.80Y	117.4	0.00	2.57	156.42	0	1092	542	90	0.00	0.0	1.689	0.000	0	0	0	0
		B		7.79Y	117.4	0.00	2.62	156.49	0	1092	542	90					0	0	0	0
		C		7.79Y	117.4	0.00	2.64	156.52	0	1092	542	90					0	0	0	0
EB5-UG2	SW2182-B	A	80E S&C S1	7.80Y	117.4	0.00	2.57	78.23	0	546	272	90	0.00	0.0	1.689	0.000	0	0	0	0
		B		7.79Y	117.4	0.00	2.62	78.26	0	546	272	90					0	0	0	0
		C		7.79Y	117.4	0.00	2.64	78.28	0	546	272	90					0	0	0	0
UG2186	EB5-UG2	A	4/0AL 220E	7.80Y	117.4	0.01	2.58	78.23	24	546	272	90	0.08	0.0	1.696	0.007	0	0	0	0
		B		7.79Y	117.4	0.01	2.63	78.26	24	546	272	90					0	0	0	0
		C		7.79Y	117.4	0.01	2.65	78.28	24	546	272	90					0	0	0	0
UG2187	UG2186	A	4/0AL 220E	7.80Y	117.4	0.01	2.59	78.23	24	546	272	90	0.16	0.0	1.711	0.015	0	0	0	0
		B		7.79Y	117.4	0.01	2.64	78.27	24	546	272	90					0	0	0	0
		C		7.79Y	117.3	0.01	2.66	78.28	24	546	272	90					0	0	0	0
UG2188	UG2187	A	4/0AL 220E	7.79Y	117.4	0.01	2.60	78.24	24	546	272	90	0.13	0.0	1.722	0.012	0	0	0	0
		B		7.79Y	117.4	0.01	2.65	78.27	24	546	272	90					0	0	0	0
		C		7.79Y	117.3	0.01	2.67	78.28	24	546	272	90					0	0	0	0
UG2189	UG2188	A	4/0AL 220E	7.79Y	117.4	0.02	2.62	78.24	24	546	272	90	0.30	0.0	1.750	0.027	0	0	0	0
		B		7.79Y	117.3	0.02	2.67	78.28	24	546	272	90					0	0	0	0
		C		7.79Y	117.3	0.02	2.69	78.29	24	546	272	90					0	0	0	0
UG2190	UG2189	A	4/0AL 220E	7.79Y	117.4	0.00	2.63	78.26	24	546	272	90	0.03	0.0	1.759	0.009	546	272	0	0
		B		7.79Y	117.3	0.00	2.68	78.29	24	546	272	90					546	272	0	0
		C		7.79Y	117.3	0.00	2.69	78.30	24	546	272	90					546	272	0	0
P UG2191	UG2189	A	4/0AL 220E	7.79Y	117.4	0.00	2.62	-0.00	0	0	0	100	0.00	0.0	1.755	0.005	0	0	0	0 P
P		B		7.79Y	117.3	0.00	2.67	-0.00	0	0	0	0					0	0	0	0 P
		C		7.79Y	117.3	0.00	2.69	-0.00	0	0	0	0					0	0	0	0
EB5-UG1	SW2182-B	A	80E S&C S1	7.80Y	117.4	0.00	2.57	78.19	0	546	271	90	0.00	0.0	1.689	0.000	0	0	0	0
		B		7.79Y	117.4	0.00	2.62	78.23	0	546	271	90					0	0	0	0
		C		7.79Y	117.4	0.00	2.64	78.24	0	546	271	90					0	0	0	0

Figure 7 Geographical design I

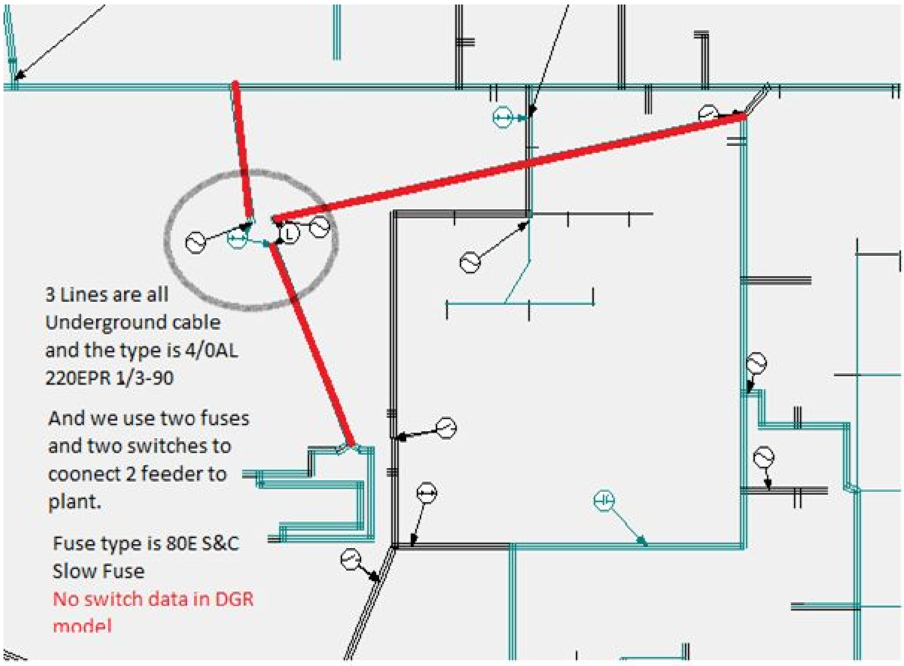


Figure 8 Geographical design II

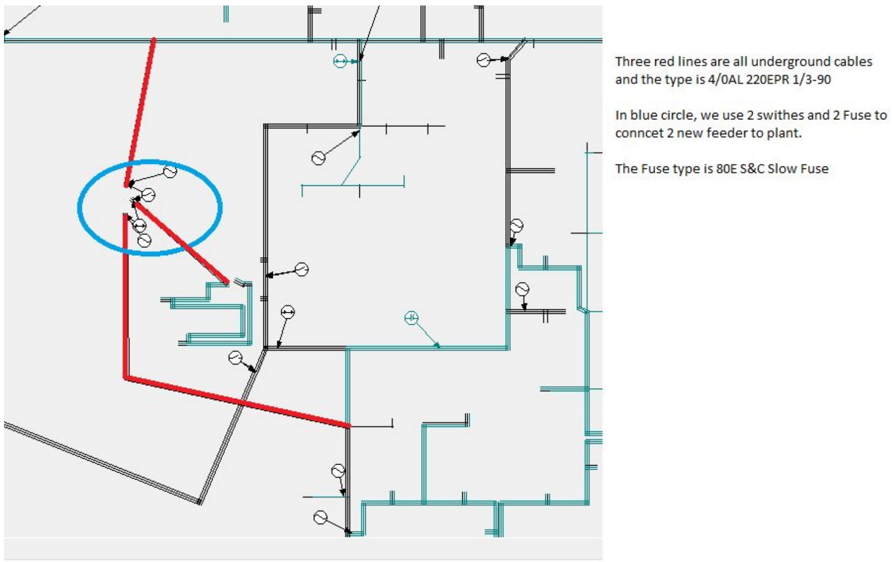


Figure 9 Geographical design III

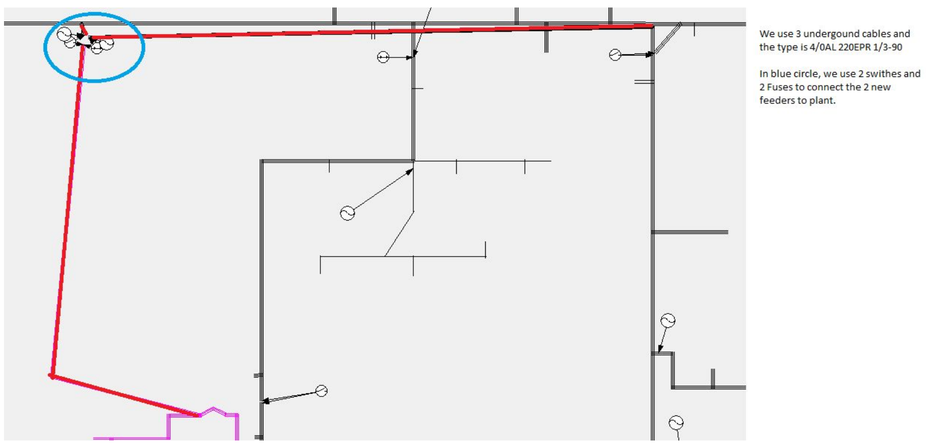


Figure 10 Model I Cable Type

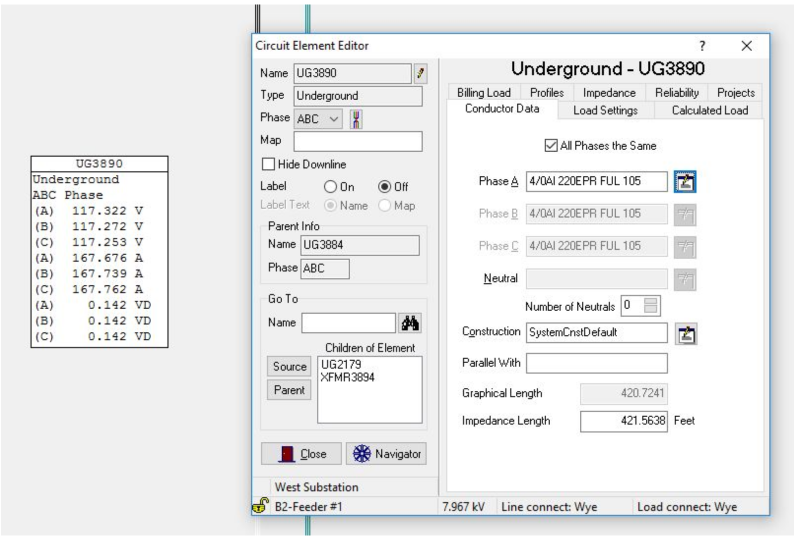


Figure 11 Model I Cable Type

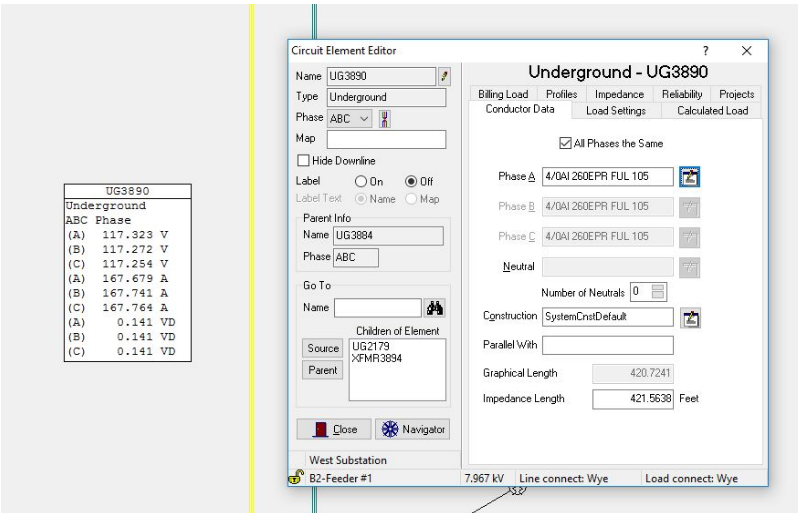


Figure 12 Model I Cable type

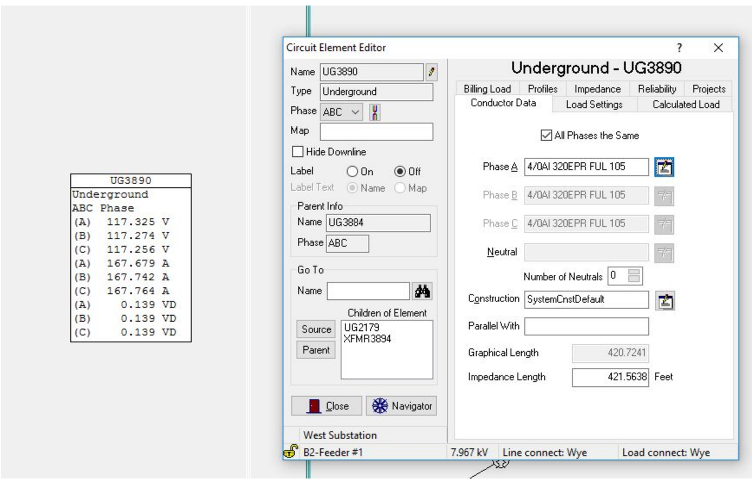


Figure 13 OH-UG Riser Specification

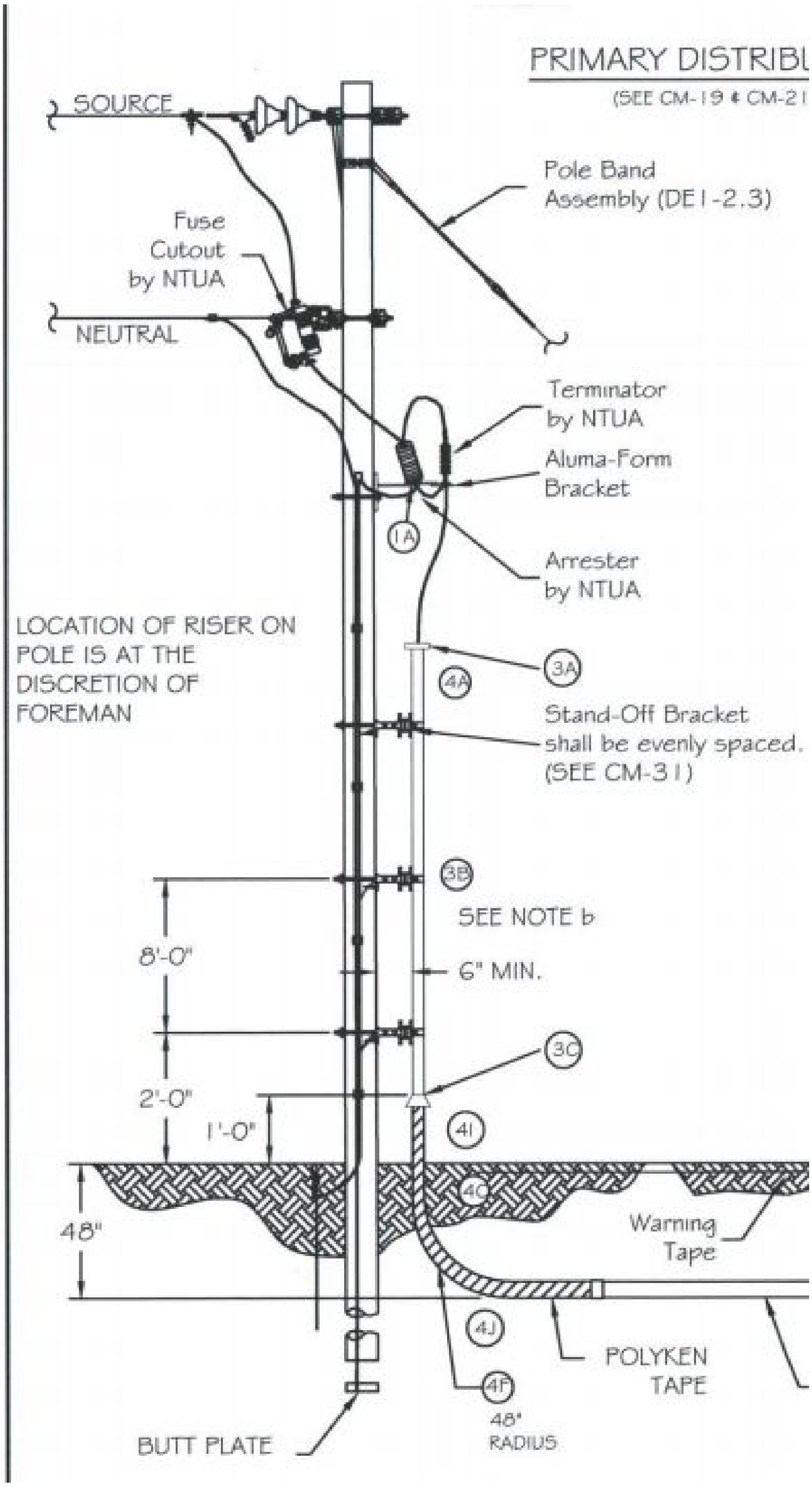
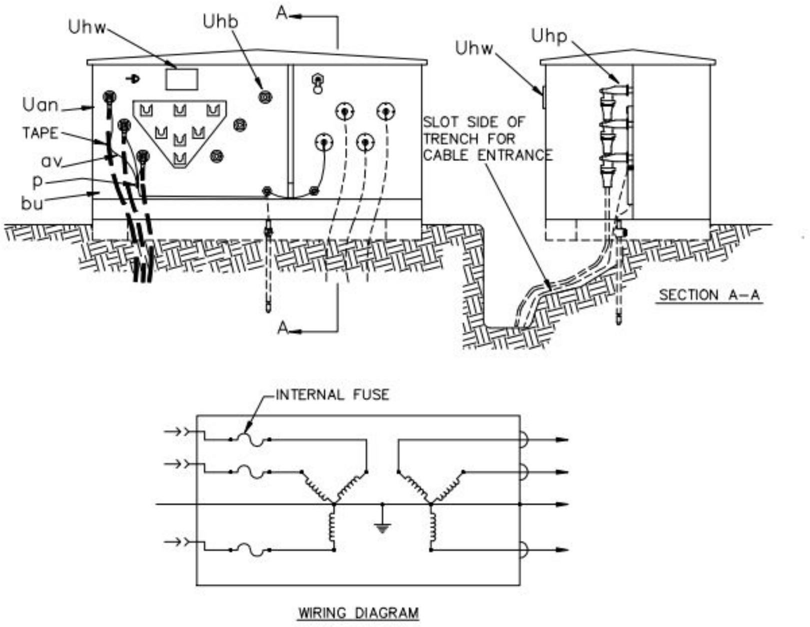


Figure 14 Pad Mounted Transformer Specification



DESIGNATE AS:

TRANSFORMER WITHOUT SECONDARY BREAKERS	TRANSFORMER WITH SECONDARY BREAKERS	
UG17–3	UG17–3B	UNIT WITH INTERNAL FUSE

NOTES:

1. ONLY THE WYE–WYE CONNECTION SHOULD BE USED TO AVOID FERRORESONANCE.
2. PROVIDE SUFFICIENT PRIMARY NEUTRAL PIGTAIL AND CABLE SLACK TO PERMIT READY DISCONNECTION OF ELBOW AND MOUNTING ON PARKING STAND. TRAIN CABLES AS SHOWN.
3. INSTALL WITH GROUNDING ASSEMBLY TO BE SPECIFIED SEPARATELY.
4. SPECIFY PAD OR SLEEVE UNIT SEPARATELY.
5. INSTALL "DANGER" SIGN ON TRANSFORMER INSIDE ENCLOSURE. INSTALL "WARNING " SIGN ON OUTSIDE SURFACE OF ENCLOSURE.

ITEM	QTY.	MATERIAL
p		Connectors, as required
av		Jumpers, copper, as required
bu	2	Connector, equipment ground
Uan	1	Transformer, pad mounted, three phase,
		with two load break bushings per phase
		and internal fuse.
Uhb	3	Insulated covers
Uhw	2	Signs, "DANGER" and "WARNING"
Uhp	3	Elbow termination
		Tape, as required
		Ground wire (See Note #3)

THREE PHASE PAD MOUNTED LOOP FEED TRANSFORMER WITH RADIAL FEED	
2000	UG17–3 UG17–3B