Section 4.3.2 has been updated since the December 2004 publication. Please refer to the on-line version for updates prior to using, see updates in red. InFPL/Power Systems/Reliability/DEO/Publications/DERM

4.3.2 TRANSFORMERS, SECONDARY, SERVICES

A. GENERAL INFORMATION

1. Introduction

When describing a distribution system, it seems natural to discuss the various components in the order in which power flows, starting at the substation and proceeding to feeders, then to laterals, then to transformers, secondaries, and services. In designing a system, however, it is necessary to start with the customers and work back to the substation. The purpose of the whole system is to serve the customers adequately and reliably; therefore, the configuration of the lines and hardware are determined by the customers - where they are, how much load they have, and what kind of service they require.

The customers' loads determine the secondary design and the size and placement of transformers. This in turn determines the routes and loading of laterals, which in turn determines whether feeder extensions or additions are required.

The choice of overhead vs. underground service is generally not an engineering decision. The choice will probably be based on city or county ordinances and/or the preferences of the owners and developers.

The information, examples, and calculations in this section are presented with the assumption that an entire residential subdivision of several blocks' extent is to be designed and built at the same time. In this case, every possible decision has to be made, and a large number of options are open. In real life, of course, many jobs must be engineered where most of the system is already in existence, and one or a few homes are being built. It may be that existing homes or commercial buildings are being modernized or enlarged. In these cases, there are more constraints and fewer options open to the designer. However, the same investigations, calculations, and checks need to be made as if all-new construction were involved; this is necessary in order to make sure that all facilities are able to carry the existing loads plus those being added.

2. Transformers

The various types of transformers available are described in Section 3.9 of this manual. Additional transformer loading and installation design information is given in Section 2.1.8; it is especially useful for designing three phase installations, large commercial or industrial service, and other out-of-the-ordinary cases.

Table IV-A provides voltage drop and voltage flicker information for overhead transformers.

3. Secondaries

Secondaries may be single or three phase. They may also be cable or open wire.

a. Cabled Secondary

Cabled secondary is somewhat more expensive than open wire secondary. It is also heavier than open wire because of the weight of the insulation. Unless properly guyed, excessive sag can result.

One advantage of cabled secondary is that its reactance is much less than open wire secondary. This results from the close spacing. Thermal loading limits are lower than those of equal size open wire because of the insulation.

In recent years our standard aluminum secondary cable has been a lashed #4/0 parallel cable with a #3/0 AWAC neutral. As part of FPL's standardization effort, the use of this cable has now been discontinued. #3/0 triplex is now standard for new installations. The existing #4/0 cable will of course remain in service throughout the system and maintenance materials will continue to be available.

Since #3/0 triplex has a #1/0 neutral, it will not be possible to pull it to anywhere near the tension used with #4/0 cable; thus the sags will be considerably greater, and maximum span lengths will be shorter.

See DCS L-5 for methods of attaching and dead-ending triplex secondary.

Table IV-A provides voltage drop and voltage flicker information for overhead cables.

4. Service Drops

Service drops are normally triplexed aluminum cable, self supported on the AAAC neutral, which also acts as a messenger. This cable is available in sizes #2, #1/0 and #3/0 triplex. The #1/0 has a #2 neutral and the #3/0 a #1/0 neutral. The above cables are used for single phase, three wire 120/240 volt service. #1/0 triplex is typically the minimum size used for new single-family home installations.

For three phase secondary and services, aluminum quadruplex cable is available in the following standard sizes: #1/0, #3/0, 336 kcmil, and 556 kcmil. The use of single conductor 336 and 556 cables for lashed services has been discontinued, as has the use of #2 quadruplex. The 336 and 556 quadruplex both utilize a #3/0 bare neutral.*

A #6 aluminum duplex cable, which is used mostly for service to multiple street lighting circuits, is also available.

Ampacities of these cables are shown in DCS F-7.1.0. Generally, voltage drop and loss considerations control the sizing of service drop cables rather than thermal limits. For typical residential services of normal length, it is seldom that a cable larger than #1/0 aluminum is required.

During hurricanes, many prolonged outages are caused by tree limbs falling on services. In many cases, the service attachment is torn off the building and the customer's weatherhead and conduit comes with it. An electrician must be called in by the customer to fix this **adding delay to service restoration**. In selecting locations for meters and service drop attachments, be sure that a substantial attachment can be made (see DCS L-2.0.0 and L-3.0.0).

*DCS Standards, such as I-4.3, call for 336 and 556 aluminum risers or jumpers. These risers/jumpers should be fashioned from short pieces of similar sized quadruplex cables.

Aluminum service drop cables are satisfactory for use in copper areas. Special attention must be paid to the connection of the aluminum conductors to the copper secondary.

B. DESIGN OF TRANSFORMERS, SECONDARIES, AND SERVICES

1. Determine Base Load of Residential Units

It is necessary to obtain first a scale site plan of the subdivision, and detailed information about the proposed customers' load. This is usually obtained from the developer. (See SPO Procedures No. 21010.)

Determine the base load of the dwelling units. Table I may be used for this purpose. For full electric (FE) homes the base load is a function of air conditioner (A/C) size and may be read directly from the table. For partial electric (PE) homes having gas (or other energy forms) water heating and/or cooking, the base load may be determined by adding the A/C load to the appropriate PE load described in the left-hand column of the table. Examples of these load determinations are shown following Table I.

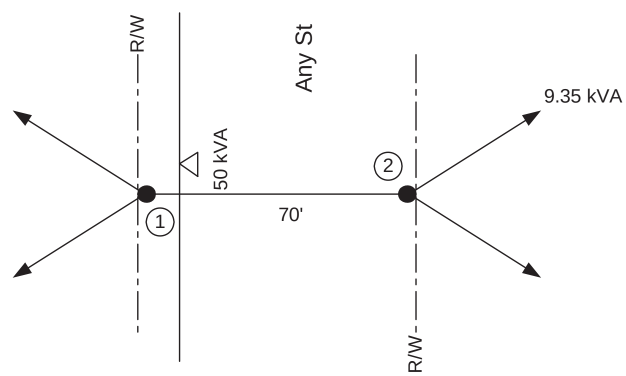
The base loads of Table I assume reverse-cycle air conditioning. For homes having electric strip heating, however, Table I may not be adequate. In many cases the strip heating rating may be substantially larger than the A/C rating. A comparison between A/C load and strip heating load must be made to determine transformer rating requirements. The kVA demand for different strip heat kW sizes is shown in Table IA. An example for calculating strip heating load is given following Table 1.

2. Determine Transformer Sizes and Locations

Lay out the secondary in each block, and select locations for transformers. Use Table III to determine the transformer size. The initial transformer installation should not exceed a 75 kVA. As an alternative, a "transformer-on-every-pole" arrangement, with no secondary, is acceptable if it can be shown to be a better solution.

A typical design example is given below.

Given: Customers with 3 ½ ton A/C. Lot size = 75 feet. Full electric service. Services to be 60 ft.



From Table III, 4 full electric customers with 3 ½ ton A/C require a 50 kVA transformer.

3. Size Service Cable

Determination of cable sizes can be done on the basis of load. However, installing cable which will be loaded near its thermal capacity will probably result in an unacceptable voltage drop and flicker situation; therefore it is wise to try a conservative design, and check the voltage drop carefully.

Florida Public Service Commission Rule 25-6.046 states that each utility shall adopt standard nominal voltages conforming to modern usage, and that the voltage at the point of delivery shall not exceed 5% above or below this nominal voltage to customers whose principal usage is for lighting and/or residential purposes, or 7-1/2% above or below this nominal voltage to customers whose principal usage is for industrial or power purposes. Furthermore, sudden changes in voltage that exceed 5% of the standard voltage and occur more frequently than two times per hour, or changes of 2-1/2% that occur more frequently than once per minute shall be "limited in magnitude and frequency of occurrence compatible with the customer's requirements". Referred to a base of 120V, this means that the customer's service voltage must not be more than 126V or less than 114V, and that flicker due to motor starting, etc., must not dip the voltage by more than 6 volts.

It is important to realize that the entire percentage of voltage drop takes place partly in the primary system, and partly in the transformer, secondary, and service.

The feeder voltage is regulated at the substation. In some locations it is necessary to add line regulators at a point on a feeder remote from the substation. (See Section 2.2.2, this manual, for a detailed discussion of feeder regulation and compensation.) Feeder voltage is regulated so as to have nominal voltage at approximately the load center. The effect of this is that the primary voltage near the substation is higher than the nominal voltage - possibly by as much as 5% - while at the far end of the feeder, the voltage may be 1% or so below nominal voltage. Any drop in the laterals is in addition to the drop already encountered on the feeder.

Thus a new customer near the substation should have no difficulty with low voltage; however, if they are out near the end of the feeder, or will be served from a long lateral, it is very likely that at their transformer the primary voltage may be 1% or so below nominal voltage. That leaves a maximum permissible drop of 4% in the transformer, secondary, and service. Conservative design practices dictate that a somewhat lesser drop – 3 ½ % - be the target (4% maximum) for a new installation electrically distant from the source of regulation and that 4% be the target (5% maximum) flicker.

When planning to serve a large load or a fairly extensive residential subdivision, the engineer or service planner should confer with the planning engineer responsible for the Area, and get as accurate a picture as possible of the voltage conditions on the feeder or lateral involved.

With all this in mind, proceed to calculate the maximum secondary current, which will occur between Pole #1 and Pole #2.

$$Secondary\,Current = \frac{Max.diversified\;kVA load\;\;x\;1000}{Operating\,Voltage}$$

Here the operating voltage is 240V. The diversified kVA to be considered is that of the 2 customers being served from Pole #2.

From Table II, 2 full-electric customers with 3 ½ ton A/C represent a total diversified demand of 15.90 kVA or 15,900 VA.

$$Secondary\;\;Current\;\; = \frac{15{,}900\,VA}{240\,V} \;\; = \;\; 66\,amps$$

From DCS F-7.1.0, we see that #3/0 Triplex, with an ampacity (summer) of 235 amps, would be acceptable. For the service cable, #1/0 Triplex will be adequate for homes with the given loads.

4. <u>Check Voltage Drop and Flicker</u>

Now consider the worst voltage drop condition seen from the transformer to a customer to determine if the cables have been adequately chosen. The worst case is from the transformer location (Pole #1) to a customer being serviced from Pole #2. This voltage drop will be the sum of the voltage drops of the transformer, the drop from Pole #1 to Pole #2, and the drop from Pole #2 to the customer.

The transformer voltage drop per kVA is taken from Table IV-A. Power factor is assumed to be 0.9. The total diversified load, from Table II, is 27.16 kVA.

Transformer Voltage Drop = $0.0382 \times 27.16 = 1.04\%$

The voltage drop in the 70' span of #3/0 Triplex from Pole #1 to Pole #2 is calculated as follows:

$$Voltage\,Drop\,Servie = \frac{span}{100}\,x\;\;Percent\,Drop\,For\,100'\,x\,Diversified\;kVA$$

Voltage Drop Pole1 to Pole2 = (70 / 100) x 0.0450 x 15.9 = 0.50%

The service voltage drop is calculated for 60 ft. of #1/0 Triplex with a load of 9.35 kVA. (This load is from Table II, for one FE customer with 3 ½ ton A/C.)

Total voltage drop = 1.04% + 0.50% + 0.39% = 1.93%

Since this drop is below 3 ½ %, the configuration selected has the correct size.

The only task remaining is to check the percent of flicker due to starting a 3 ½ ton A/C at the farthest house from the transformer. Referring to Table IV-A:

Voltage drop in transformer			=	1.467
Voltage drop in secondary	=	0.7 × 1.316	=	0.921
Voltage drop in service	=	0.6 × 1.964	=	1.178
Total Voltage drop			=	3.566

This is close to the design target of 3.5% and well below the maximum allowed drop due to starting current, which is 4%.

Calculate the drops for the worst cases; if they show that satisfactory voltage will be obtained, then so will the others.

5. Additional Example of Transformer Selection

The preceding example was based upon the assumption that an entire subdivision, or a group of several houses, at least, was being developed all at once. Another example is given below to show how the transformer installation is designed in a somewhat different situation.

Remember that for installations to serve new loads, the transformer should be sized so that it is initially loaded to about 100% (120% if homes are less than 2500ft^2) of its nameplate rating. It is usually necessary to consider the economics of two or more transformer-secondary combinations. The following steps are necessary:

Obtain data on equipment customers will use; classify the customers into the following groupings:

a. Lights and refrigeration.

b. Partial electric; (a) above plus range.

c. Partial electric; (a) above plus water heater.

d. Full electric; (a) above plus range and water heater.

e. Full electric; (d) above plus (X) tons of A/C.

Use the tables in this Section to determine the total diversified demand for the group of customers on the proposed secondary. Attempt to choose the transformer whose full load rating most nearly matches 100% of the demand of the group of customers. Summer and Winter demand must be equal to or less than 100% (120% if homes are less than 2500 ft^2) and 170%, respectively, of the transformer rating. The greater loading in the winter is justified because the heating load factor is much lower than the cooling load factor.

As an example, suppose there are 6 homes with Full Electric. Three homes have 3 tons (36,000BTU) A/C and 3 homes have 4 tons (48,000BTU) A/C. There is no resistance heating.

Refer to Tables I and II. Diversity Factors and Loads are:

Diversity Factor: 6 FE = 0.576; 6 A/C = 0.75

Load, kVA, FE = 4.29 (3T A/C); FE = 5.67 (4T A/C)

Load, kVA 3T A/C = 3.79; 4T A/C = 5.05

$$\text{TOTAL LOAD} = 0.57((3 \times 4.29)+(3 \times 5.67)) + 0.75((3 \times 3.79)+(3 \times 5.05))$$
$$= 17.03 + 19.89$$
$$= 36.92 \text{ kVA}$$

A 50 kVA transformer is sufficient for this installation. For homes with split A/C units, treat the bedroom section as a Partial Electric (PE) home with the appropriate tonnage A/C and the living area as a Full Electric (FE) home with the related A/C unit. Combine the results using diversity factors for the full number of A/C's.

Instead of being reverse cycle units, the units might have strip heaters with kW ratings exceeding the kVA rating of the A/C unit.

In this case, tentatively size the transformer based on loads other than the strip heating load. Then check the transformer loading with the A/C replaced by the strip heater load. Use the information under Table I-A to obtain the contribution towards individual home demand attributable to the heating load. Since the ambient temperature will be lower at the time of space heating peak load, the transformer loading for the winter should be considered for as much as 170% of its summer loading.

For example, suppose the 3 ton units in the previous example were equipped with 10 kW and the 4 ton units with 12 kW strip heaters.

As before, the full electric component of the load is 17.03 kVA. From the data under Table I-A, and interpolating:

12 kW strip heating = 8 + (10.5-8)/(15-10) (12-10) = 9 kVA Demand

Strip heating Component of total Demand

Diversity factor for six customers = 0.75

= 0.75 ((3 × 9) + (3 × 8)) = 0.75 (27.0 + 24.0) = 38.25

Total Diversified Demand = 17.03 + 38.25 = 55.28 kVA

Ratio of winter to summer load = 55.28/36.92 = 1.50 = 150%

Since this ratio is below 170%, the size of the transformer will be determined by the 36.92 kVA of summer load. A 50 kVA transformer would be used.

6. <u>Adding New Load to Existing Residential Transformer</u>

It is often necessary to connect a new customer or customers to an existing transformer secondary installation. It may be possible to do this without changing out the transformer. As a general rule for residential subdivisions, customers may be added as long as the new summer loading will not exceed 140% of transformer rating.

Actual existing loading on the bank should be used in conjunction with Table I (to determine demand of the new customer or customers). Apply a diversity factor based on the total number of customers for the new non-air conditioning load and on total number of air conditioning customers for the new A/C load. Add this to the known existing transformer demand. If the resulting load does not exceed 140% of the transformer rating, no additional capacity is needed. Transformer voltage drop will increase, so recheck voltage conditions on the new transformer-secondary-service combination.

If actual loading is not available, obtain data on existing connected customers plus new customers and handle as though it were a new installation, except that the transformer can be loaded up to 140%, based on summer peak.

Normally, TLM data will be a good source of data on existing customers. If for some reason, TLM information cannot be used, one of the following methods may be utilized:

1. Make 24-hour ampere demand measurements. (This works best on hot summer or cold winter days.)
2. Obtain 12-month maximum kWh consumption for each customer on the secondary bus, and use Table V to convert kWh to kW demand. See sample calculations following table.
3. Assume that each customer on the transformer has the same load as the customers being added.

TABLE I
STANDARD LOADS (kVA) BASED ON A/C SIZE

	1 TON	1-1/2 TON	2 TON	2-21/2 TON	3 TON	3-1/2 TON	4 TON	5 TON
LIGHTS & REFRIG	0.71	0.74	0.78	0.82	0.86	0.99	1.14	1.5
PARTIAL ELECTRIC (PE)								
1. PE w/ WH only	2.11	2.22	2.33	2.45	2.57	2.96	3.40	4.49
2. PE w/ Range only	2.82	2.96	3.11	3.27	3.43	3.94	4.54	6.00
FULL ELECTRIC (FE)	3.53	3.71	3.89	4.09	4.29	4.93	5.67	7.5
AIR CONDITIONER (A/C with EER OF 9.5)	1.26	1.89	2.53	3.16	3.79	4.42	5.05	6.32
FE w/ A/C	4.79	5.6	6.42	7.2	8.08	9.35	10.72	13.82

Note: If customer's A/C consists of several small units, apply appropriate A/C diversity factor from Table II to A/C kVA above to determine his A/C load.

The bottom row of the table marked "FE with A/C" gives base kVA loads for full electric customers with the A/C sizes as indicated at the tops of the columns. Base loads for partial electric customers may be obtained by adding the appropriate PE load (in the column under the A/C size) to the A/C load. For example, a **mobile home park** may have 2 ton A/C's and be partial electric with gas water heating. In this case the base load would be 3.11 kVA (PE) + 2.53 kVA (A/C) = 5.64 kVA total.

TABLE I-A

Use the table below for dwelling units with electric resistance heating:

kW Rating	kVA Demand	kW Rating	kVA Demand
5	5	15	10.5
10	8	20	14.0

Base load for dwelling units having strip heating may be determined by adding the strip heating load to the appropriate PE or FE load. Thus the base load for the FE dwelling unit having 3 tons of A/C and 10 kW strip heating would be:

4.29 kVA (FE) + 8.0 kVA (strip heating) = 12.29 kVA total.

For example, a subdivision of single family homes is developed, each home having a 5 ton A/C and a 15 kW strip heater. The homes are full electric. From Table I, base load with A/C is 13.82 kVA. Base load with strip heating is 7.50 kVA (FE) + 10.5 kVA (strip heater) = 18.0 kVA total. The base load with strip heater is 30% greater than base load with A/C. However, winter loading is allowed to be 70% greater than summer due to the lower ambient temperatures (see Section 2.1.8 of this manual). Therefore, the A/C load determines the base load to use in selecting transformer size.

TABLE II

STANDARD FE LOADS DIVERSIFIED FOR 1 THROUGH 20 CUSTOMERS

NO. OF CUST.	DIVERSITY FACTOR (D)		1 TON			1-1/2 TON			2 TON			2-1/2 TON		
	FE	A/C	FE	A/C	TOTAL	FE	A/C	TOTAL	FE	A/C	TOTAL	FE	A/C	TOTAL
1.00	1.00	1.00	3.53	1.26	4.79	3.71	1.89	5.60	3.89	2.53	6.42	4.09	3.16	7.25
2.00	0.85	0.85	6.00	2.14	8.14	6.31	3.21	9.52	6.61	4.30	10.91	6.95	5.37	12.33
3.00	0.74	0.83	7.84	3.14	10.97	8.24	4.71	12.94	8.64	6.30	14.94	9.08	7.87	16.95
4.00	0.66	0.80	9.32	4.03	13.35	9.79	6.05	15.84	10.27	8.10	18.37	10.80	10.11	20.91
5.00	0.61	0.77	10.77	4.85	15.62	11.32	7.28	18.59	11.86	9.74	21.61	12.47	12.17	24.64
6.00	0.57	0.75	12.07	5.67	17.74	12.69	8.51	21.19	13.30	11.39	24.69	13.99	14.22	28.21
7.00	0.54	0.73	13.34	6.44	19.78	14.02	9.66	23.68	14.70	12.93	27.63	15.46	16.15	31.61
8.00	0.52	0.72	14.68	7.26	21.94	15.43	10.89	26.32	16.18	14.57	30.76	17.01	18.20	35.22
9.00	0.50	0.71	15.89	8.05	23.94	16.70	12.08	28.77	17.51	16.17	33.67	18.41	20.19	38.60
10.00	0.49	0.70	17.30	8.82	26.12	18.18	13.23	31.41	19.06	17.71	36.77	20.04	22.12	42.16
11.00	0.47	0.70	18.25	9.70	27.95	19.18	14.55	33.73	20.11	19.48	39.59	21.15	24.33	45.48
12.00	0.46	0.69	19.49	10.43	29.92	20.48	15.65	36.13	21.47	20.95	42.42	22.58	26.16	48.74
13.00	0.45	0.69	20.65	11.30	31.95	21.70	16.95	38.66	22.76	22.69	45.45	23.93	28.35	52.27
14.00	0.43	0.68	21.25	12.00	33.25	22.33	17.99	40.33	23.42	24.09	47.50	24.62	30.08	54.71
15.00	0.42	0.68	22.24	12.85	35.09	23.37	19.28	42.65	24.51	25.81	50.31	25.77	32.23	58.00
16.00	0.41	0.67	23.16	13.51	36.66	24.34	20.26	44.60	25.52	27.12	52.64	26.83	33.88	60.71
17.00	0.39	0.67	23.40	14.35	37.76	24.60	21.53	46.12	25.79	28.82	54.61	27.12	35.99	63.11
18.00	0.38	0.66	24.15	14.97	39.11	25.38	22.45	47.83	26.61	30.06	56.66	27.98	37.54	65.52
19.00	0.38	0.66	25.49	15.80	41.29	26.79	23.70	50.49	28.09	31.73	59.81	29.53	39.63	69.16
20.00	0.37	0.65	26.12	16.38	42.50	27.45	24.57	52.02	28.79	32.89	61.68	30.27	41.08	71.35

TABLE II (CONT'D)

NO. OF CUST.	DIVERSITY FACTOR (D)		3 TON			3-1/2 TON			4 TON			5 TON		
	FE	A/C	FE	A/C	TOTAL	FE	A/C	TOTAL	FE	A/C	TOTAL	FE	A/C	TOTAL
1.00	1.00	1.00	4.29	3.79	8.08	4.93	4.42	9.35	5.67	5.05	10.72	7.50	6.32	13.82
2.00	0.85	0.85	7.29	6.44	13.74	8.38	7.51	15.90	9.64	8.59	18.22	12.75	10.74	23.49
3.00	0.74	0.83	9.52	9.44	18.96	10.94	11.01	21.95	12.59	12.57	25.16	16.65	15.74	32.39
4.00	0.66	0.80	11.33	12.13	23.45	13.02	14.14	27.16	14.97	16.16	31.13	19.80	20.22	40.02
5.00	0.61	0.77	13.08	14.59	27.68	15.04	17.02	32.05	17.29	19.44	36.74	22.88	24.33	47.21
6.00	0.57	0.75	14.67	17.06	31.73	16.86	19.89	36.75	19.39	22.73	42.12	25.65	28.44	54.09
7.00	0.54	0.73	16.22	19.37	35.58	18.64	22.59	41.22	21.43	25.81	47.24	28.35	32.30	60.65
8.00	0.52	0.72	17.85	21.83	39.68	20.51	25.46	45.97	23.52	29.09	52.68	31.20	36.40	67.60
9.00	0.50	0.71	19.31	24.22	43.52	22.19	28.24	50.43	25.52	32.27	57.78	33.75	40.38	74.13
10.00	0.49	0.70	21.02	26.53	47.55	24.16	30.94	55.10	27.78	35.35	63.13	36.75	44.24	80.99
11.00	0.47	0.70	22.18	29.18	51.36	25.49	34.03	59.52	29.31	38.89	68.20	38.78	48.66	87.44
12.00	0.46	0.69	23.68	31.38	55.06	27.21	36.60	63.81	31.30	41.81	73.11	41.40	52.33	93.73
13.00	0.45	0.69	25.10	34.00	59.09	28.84	39.65	68.49	33.17	45.30	78.47	43.88	56.69	100.57
14.00	0.43	0.68	25.83	36.08	61.91	29.68	42.08	71.76	34.13	48.08	82.21	45.15	60.17	105.32
15.00	0.42	0.68	27.03	38.66	65.69	31.06	45.08	76.14	35.72	51.51	87.23	47.25	64.46	111.71
16.00	0.41	0.67	28.14	40.63	68.77	32.34	47.38	79.72	37.20	54.14	91.33	49.20	67.75	116.95
17.00	0.39	0.67	28.44	43.17	71.61	32.69	50.34	83.03	37.59	57.52	95.11	49.73	71.98	121.71
18.00	0.38	0.66	29.34	45.03	74.37	33.71	52.51	86.23	38.78	59.99	98.78	51.30	75.08	126.38
19.00	0.38	0.66	30.97	47.53	78.50	35.59	55.43	91.02	40.94	63.33	104.26	54.15	79.25	133.40
20.00	0.37	0.65	31.75	49.27	81.02	36.48	57.46	93.94	41.96	65.65	107.61	55.50	82.16	137.66

USE OF TABLE

The load for one customer is the base load and is taken from TABLE I. the total load (L_n) for n identical customers is L_n=n (base A/C load) $D_{n(A/C)}$+ (base other load) D_n (other). For strip heating load, substitute strip heater kVA for base A/C load. Use A/C diversity factor ($D_{A/C}$) for all cooling and heating. "Base other load" may be FE, PE or other customer load not including heating or cooling. Using this formula, the total load for the 10 mobile homes depicted in the prior example shown under TABLE I would be L_{10}= 10 (2.53) (0.70) + (3.11) (0.49) = 32.9kVA.

TABLE III
TRANSFORMER LOADING - FE CUSTOMERS

Transformer size	Number of Full Electric Homes							
	1 Ton	1 ½ Ton	2 Ton	2 ½ Ton	3 Ton	3 ½ Ton	4 Ton	5 Ton
25 kVA	1-11	1-8	1-7	1-6	1-5	na	na	na
50 kVA	20	9-20	8-17	7-14	6-12	1-10	1-8	na
75 kVA	-	-	18+	15-20	13-20	11-17	9-14	1-10
100 kVA	-	-				18+	15-20	11-15

Voltage and flicker calculations are required and can frequently be the determining factor in transformer sizing

USE OF TABLE

For FE customers, use this table to select transformer size after designing transformer-secondary arrangements. For example, what size transformer would be required for 4 homes with 4 ton A/C's? Enter the chart under "4 TON" and move downward to the row which has 4 customers, in this case "1 - 8". Move left to "50 kVA".

This table is for standard FE loads based on A/C size. Transformer sizes for PE loads or loads determined by strip heating must be calculated as shown under Tables I and II.

Note that initial loading of transformers is to be kept to about 100% (120% if homes less than 2500ft^2) of transformer nameplate.

TABLE IV-A
PER CENT VOLTAGE DROP/FLICKER AT 240 VOLTS - TRANSFORMERS AND OVERHEAD CABLES

PERCENT VOLTAGE DROP PER kVA AT 240 VOLTS (Single Phase)										
Power Factor	Transformer kVA (Single Phase Aerial) (1)						OH 3/C Cables; Per 100 Circuit Feet				
%	10	25	50	75	100	167	#2A TPX	#1/0A TPX	#3/0A TPX	336A QPX	556A QPX
100.0	0.1600	0.0520	0.0240	0.0105	0.0084	0.0052	0.1163	0.0733	0.0458	0.0229	0.0139
95.0	0.1926	0.0719	0.0347	0.0180	0.0146	0.0089	0.1135	0.0720	0.0463	0.0245	0.0161
90 (2)	0.2007	0.0782	0.0382	0.0206	0.0168	0.0103	0.1089	0.0693	0.0450	0.0244	0.0165
85.0	0.2045	0.0821	0.0404	0.0224	0.0183	0.0112	0.1040	0.0664	0.0436	0.0240	0.0167

PERCENT VOLTAGE DROP DUE TO STARTING CURRENT (Flicker) - A/C 240 Volt (Single Phase)												
A/C Size	A/C System Starting Current (4)	Transformer kVA; 1-Ph Aerial (1)						OH 3/C Cables; Per 100 Circuit Feet				
Tons		10	25	50	75	100	167	#2A TPX	#1/0A TPX	#3/0A TPX	336A QPX (3)	556A QPX (3)
1.0	40	1.972	0.839	0.419	0.243	0.200	0.122	0.871	0.559	0.375	0.216	0.158
1.5	60	2.958	1.259	0.629	0.365	0.299	0.183	1.308	0.839	0.563	0.324	0.237
2.0	80	3.944	1.678	0.838	0.487	0.399	0.243	1.747	1.120	0.751	0.433	0.316
2.5	100	4.930	2.098	1.048	0.608	0.499	0.304	2.187	1.401	0.939	0.541	0.394
3.0	120	5.916	2.517	1.257	0.730	0.599	0.365	2.628	1.682	1.127	0.649	0.473
3.5	140	6.902	2.937	1.467	0.852	0.698	0.426	3.070	1.964	1.316	0.757	0.552
4.0	160	7.888	3.356	1.676	0.973	0.798	0.487	3.513	2.247	1.504	0.866	0.631
4.5	180	8.874	3.776	1.886	1.095	0.898	0.548	3.957	2.530	1.693	0.974	0.710
5.0	200	9.860	4.195	2.095	1.217	0.998	0.609	4.403	2.813	1.882	1.082	0.789

NOTES

1. This chart is based on Aerial Transformers on current order as of 2002/04. For Pad Mount Transformer chart - see section 5.3.1.
2. 90% Power Factor is normally used for residential voltage drop calculations.
3. Figures for QPX cables are with 1 leg not used since this chart is only for Single Phase.
4. A/C System Starting Current is the maximum allowed coincident starting current of any, or all of the system’s components (compressor, condenser fan motor, and air handler blower motor). If the System Starting current exceeds the values shown, the customer should investigate the installation of either a “hard start” kit or “stage” starting (or other method recommended by the manufacturer) to reduce the starting current to the maximum level shown in the Table.

5. Percent voltage drop in the tables was calculated using the following formula:

$$\% Voltage\ Drop = \frac{(IZ)x(100)}{V} = \frac{I(R\cos\theta + X\sin\theta)(100)}{V}$$

where

I	=	current per conductor, amps
Z	=	Impedance to neutral, ohms
R	=	Resistance, ohms
X	=	Series inductive reactance, ohms
θ	=	Power factor angle, degrees
V	=	Voltage, phase to neutral, volts

To determine the percent voltage drop per kVA for 120/240 volt single phase circuits use 4.167 for I and 120 for V. The X and R values are taken from DERM 4.3.2 Table VIII.

6. To calculate voltage drop and flicker for balanced three phase systems, multiply the values in the table by .67 for 120/208V circuit or by .125 for 277/480V circuit. Use the three phase value for the kVA in the calculation.

TABLE IV - B
PER CENT VOLTAGE DROP/FLICKER AT 240 VOLTS - SINGLE PHASE OH OPEN WIRE SECONDARY

Per Cent Voltage Drop Per kVA at 240 Volts, Single Phase - 12 Inch Spacing										
Power Factor %	OPEN WIRE SECONDARY - PER 100 CIRCUIT FEET									
	#6 CU	#4 CU	#2 CU	#1/0 CU	#4T	#2T	#1/0T	#3/0T	343 ACAR	568 ACAR
100	.1751	.1099	.0707	.0444	.1797	.1130	.0711	.0449	.0231	.0140
95	.1799	.1175	.0796	.0540	.1835	.1195	.0792	.0537	.0321	.0229
90 (1)	.1766	.1172	.0809	.0565	.1796	.1187	.0802	.0558	.0350	.0260
85	.1720	.1155	.0810	.0577	.1744	.1166	.0801	.0568	.0368	.0281

		Per Cent Voltage Drop (Flicker) due to Starting Current - A/C 240 volt, Single Phase									
A/C Size (TONS)	A/C System Starting Current (2)	OPEN WIRE SECONDARY - PER 100 CIRCUIT FEET									
		#6 CU	#4 CU	#2 CU	#1/0 CU	#4T	#2T	#1/0T	#3/0T	343 ACAR	586 ACAR
1.5	45	1.729	1.180	.850	.629	1.749	1.185	.835	.614	.424	.339
2	60	2.320	1.578	1.134	.839	2.348	1.584	1.114	.819	.565	.453
2.5	75	2.917	1.978	1.419	1.049	2.954	1.986	1.394	1.024	.707	.567
3	90	3.518	2.379	1.704	1.259	3.564	2.390	1.674	1.229	.848	.680
3.5	105	4.124	2.781	1.989	1.469	4.180	2.796	1.955	1.434	.990	.794
4	120	4.733	3.185	2.275	1.678	4.800	3.203	2.236	1.638	1.132	.909
5	150	5.961	3.996	2.847	2.098	6.050	4.022	2.800	2.048	1.415	1.137

NOTES:

1. 90% Power Factor is normally used for residential voltage drop calculations.
2. A/C System Starting Current is the maximum allowed coincident starting current of any, or all of the system's components (compressor, condenser fan motor, and air handler blower motor). If the System Starting Current exceeds the values shown the customer should investigate the installation of either a "hard start" kit or "stage" starting (or other method recommended by the manufacturer) to reduce the starting current to acceptable levels.

TABLE V-A

KWh	Summer (May-Oct) kWD	Winter (Nov-Apr) kWD	kWh	Summer (May-Oct) kWD	Winter (Nov-Apr) kWD
50	1.64	1.39	1750	9.82	11.03
100	2.33	2.20	1850	10.10	11.36
150	2.86	2.83	1900	10.24	11.52
200	3.30	3.35	1950	10.37	11.68
250	3.70	3.82	2000	10.50	11.84
300	4.05	4.23	2050	10.76	12.14
350	4.38	4.62	2100	10.76	12.14
400	4.68	4.98	2150	10.89	12.29
450	4.97	5.31	2200	11.02	12.44
500	5.24	5.63	2250	11.14	12.59
550	5.50	5.94	2300	11.27	12.73
600	5.74	6.22	2350	11.39	12.83
650	5.98	6.50	2400	11.51	13.02
700	6.20	6.77	2450	11.63	13.16
750	6.42	7.03	2500	11.75	13.30
800	6.63	7.28	2550	11.86	13.44
850	6.84	7.52	2600	11.98	13.57
900	7.04	7.75	2650	12.09	13.71
950	7.23	7.98	2700	12.21	13.84
1000	7.42	8.20	2750	12.32	13.98
1050	7.60	8.42	2800	12.43	14.11
1100	7.78	8.63	2850	12.54	14.24
1150	7.96	8.84	2900	12.65	14.37
1200	8.13	9.04	2950	12.76	14.50
1250	8.30	9.24	3000	12.87	14.62
1300	8.46	9.43			
1350	8.62	9.62			
1400	8.78	9.81			
1450	8.94	9.99			
1500	9.09	10.17			
1550	9.24	10.35			
1600	9.39	10.53			
1650	9.54	10.70			
1700	9.68	10.87			

How to use the kWh/kWD Conversion Chart:

1. Find each customer's kWh usage for month investigated.
2. From Table V-A above, find kWD corresponding to each customer's kWh usage. Summer loads – Use summer table ---Winter loads – Use winter table.
3. Sum each customer's kWh on the transformer to get total undiversified demand on the transformer.

For kWh over 3000 use the following formula:

Winter: $kWD = .2774\sqrt{kWh} - 0.5702$

Summer: $kWD = .2354\sqrt{kWh} - 0.0242$

(Continued)

AVERAGE CUSTOMER KWD

NUMBER OF CUSTOMERS	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	.50	.66	.78	.87	.93	.97	.98	.98	.98	.99	.99	.99	.99	.99	.99	.99	.99	.99
3	.47	.64	.74	.82	.87	.90	.93	.95	.97	.98	.98	.98	.98	.98	.98	.98	.98	.98
4	.44	.60	.69	.75	.80	.84	.86	.88	.90	.91	.93	.95	.95	.95	.96	.97	.97	.97
5	.40	.55	.64	.70	.74	.77	.80	.82	.83	.85	.86	.87	.88	.89	.89	.90	.90	.91
6	.36	.50	.59	.65	.69	.72	.75	.76	.78	.79	.80	.81	.82	.83	.83	.84	.85	.85
7	.32	.46	.55	.60	.64	.67	.70	.72	.73	.74	.75	.76	.77	.78	.79	.79	.80	.80
8	.31	.43	.51	.56	.60	.63	.66	.68	.69	.70	.71	.72	.73	.74	.74	.75	.75	.76
9	.28	.40	.48	.53	.57	.60	.62	.64	.65	.67	.68	.69	.69	.70	.71	.71	.72	.72
10	.25	.37	.45	.50	.54	.57	.59	.61	.62	.63	.64	.65	.66	.67	.68	.68	.68	.69
11	.23	.34	.42	.47	.51	.54	.56	.58	.59	.61	.62	.62	.63	.64	.64	.65	.65	.66
12	.22	.32	.40	.45	.49	.51	.54	.55	.57	.58	.59	.60	.61	.61	.62	.62	.62	.63
13	.21	.30	.38	.43	.46	49	.51	.53	.55	.56	.57	.58	.58	.59	.59	.60	.60	.61
14	.21	.28	.36	.41	.45	.47	.49	.51	.52	.54	.55	.55	.56	.57	.57	.58	.58	.59
15	.20	.26	.34	.39	.43	.45	.48	.49	.51	.52	.53	.54	.54	.55	.56	.56	.56	.57
16	.20	.25	.32	.37	.41	.44	.46	.48	.49	.50	.51	.52	.53	.53	.54	.54	.55	.55
17	.20	.23	.31	.36	.40	.42	.44	.46	.47	.49	.50	.50	.51	.52	.52	.53	.53	.54
18	.19	.22	.30	.35	.38	.41	.43	.45	.46	.47	.48	.49	.50	.50	.51	.51	.52	.52
19	.19	.21	.28	.33	.37	.40	.42	.43	.45	.46	.47	.48	.48	.49	.49	.50	.50	.51
20	.19	20	.27	.32	.36	.38	.41	.42	.43	.45	.46	.46	.47	.48	.48	.49	.49	.50

20 CUSTOMERS WITH AN AVERAGE LOAD OF 7 KWD

TABLE V-B

COINCIDENCE FACTOR CHART

kWh/kWD Conversion Chart (Residential) (cont'd)

3. Find the coincidence factor on the Coincidence Factor Chart for the number of customers on the transformer.

   Compute the average kWD per customer, locate the number of customers down the left side of the table and then go over to the correct average kWD per customer to locate the coincidence factor. If the total number of customers is greater than 20, use the row for 20.

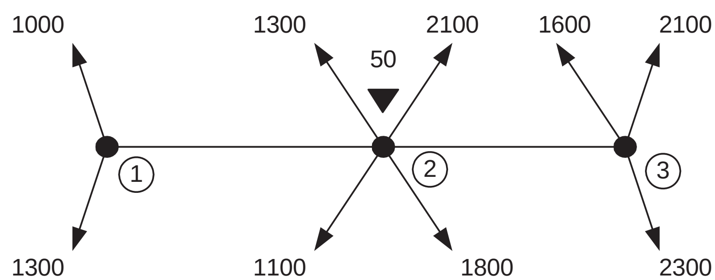
4. Multiply total kWD (step 3) by coincidence factor.

5. Answer yields peak 15 minute - kWD on transformer.

Estimation of Transformer Load using kWh Consumption.

Residential Customers (cont'd. - from charts on previous pages)

SAMPLE CALCULATION



(Numbers at Services are kWh Consumptions for a summer month)

CALCULATION OF TRANSFORMER LOADING

	kWh	kWD
POLE 1	1000	7.42
	1300	8.46
POLE 2	1300	8.46
	2100	10.76
	1100	7.78
	1800	9.96
POLE 3	1600	9.39
	2300	11.27
	2100	10.76
TOTAL OF ALL POLES		84.26

$$AveragekWD = \frac{84.26}{9} = 9.36$$

Load on transformer = 84.26 3 0.62 @ 90% power factor = 58 kVA

% Load on transformer = 58/50 = 116%

LOADING ON INDIVIDUAL POLES FOR VOLTAGE CALCULATIONS

POLE 1 (2 Custs) $15.88 \times 0.97 = 15.4$ @ .90PF = 17.1 kVA
POLE 2 (4 Custs) $36.96 \times 0.86 = 31.8$ @ .90PF = 35.3 kVA
POLE 3 (3 Custs) $31.42 \times 0.95 = 29.8$ @ .90PF = 33.2 kVA

TABLE VI

Voltage Drop Table - Three Phase 120/208 Aerial Secondary
(This is not typical of residential areas, it is more typical of commercial or light industrial.)

Aerial Lines

Voltage Drop Data

208 Volt (120/208Y)

Three Phase Secondary

$$EquivalentSpacing = \sqrt[3]{12''\times 12''\times 24''} = 15.12 inches$$

Conductor Size	"kVA x 1,000 ft" To Give 1% voltage Drop (Constant "K")					
	Percent power factor - Lagging					
	100	95	90	85	80	75
Copper						
6	0.95	0.92	0.93	0.96	0.99	1.02
4	1.52	1.40	1.40	1.41	1.44	1.47
2	2.39	2.08	2.04	2.02	2.03	2.05
1/0	3.76	3.02	2.87	2.79	2.6	2.74
2/0	4.75	3.62	3.37	3.24	3.17	3.12
4/0	7.54	5.05	4.54	4.26	4.08	3.96
AAAC						
2	1.67	1.41	1.41	1.44	1.47	1.51
1/0	2.39	2.12	2.08	2.07	2.09	2.12
3/0	3.80	3.11	2.97	2.90	2.89	2.87
343.6*	7.49	5.22	4.75	4.49	4.33	4.22
568.3*	12.33	7.27	6.35	5.84	5.52	5.29

*15/4 ACAR

$$\%VoltageDrop = \frac{\frac{kVA \times ft}{1000}}{Const''K''\ fromTable}$$

Note:

1. Table applies for balanced load.

TABLE VII

Voltage Drop Table - Three Phase 240 Volt Secondary

Aerial Lines

Voltage Drop Data

240 Volt
Three Phase Secondary

$$EquivalentSpacing = \sqrt[3]{12"\times 12"\times 24"} = 15.12 inches$$

Conductor Size	"kVA x 1000 ft." To Give 1% Voltage Drop (Constant "K")					
	Percent power factor - Lagging					
	100	95	90	85	80	75
Copper						
6	1.27	1.23	1.25	1.28	1.32	1.36
4	2.02	1.87	1.87	1.89	1.92	1.97
2	3.19	2.78	2.81	2.70	2.71	2.74
1/0	5.02	4.04	3.83	3.73	3.68	3.66
2/0	6.34	4.83	4.51	4.33	4.23	4.17
4/0	10.01	6.74	6.06	5.69	5.46	5
AAAC						
2	2.23	1.88	1.88	1.92	1.96	2.01
1/0	3.19	2.82	2.77	2.76	2.78	2.82
3/0	5.07	4.15	3.96	3.87	3.83	3.82
343.6*	9.98	6.96	6.33	5.99	5.77	5.62
568.3*	16.44	9.69	8.47	7.79	7.36	7.05

*15/4 ACAR % Voltage Drop =

$$\%VoltageDrop = \frac{\frac{kVA\times ft}{1000}}{Const"K"\ fromTable}$$

Note:

1. Table applies for balanced load.

TABLE VIII

IMPEDANCES FOR COMMONLY USED SECONDARY WIRES AND CABLES

i. OPEN WIRE SECONDARY, 12" SPACING

MATERIAL	SIZE	M&S NUMBER	IMPEDANCE - OHMS/100 CIRCUIT FEET [2] RESISTANCE (R)[1]	REACTANCE(X)
COPPER, HARD-DRAWN	#6	Reference Only	0.9030	0.2412
	#4	112-10600-1	0.5678	.02306
	#2	112-20800-9	0.3644	.02174
	#1/0	112-21100-0	0.2295	0.2068
	#4/0	112-21400-9	0.1148	0.1906
6201 AL ALLOY[3]	#2	100-55800-6	0.5748	0.2136
AAAC	#1/0	100-58900-2	0.3612	0.2032
	#3/0	100-59000-1	.02274	0.1924
ACAR (15/4)[4]	343.4 kcmil	100-6100-1	0.1154	0.1738
	556.5 kcmil	100-61200-4	0.0701	0.1622

ii. TRIPLEXED AND LASHED OVERHEAD CABLES

MATERIAL	SIZE	M&S NUMBER	IMPEDANCE - OHMS/1000 CIRCUIT FEET [2] RESISTANCE (R)[1]	REACTANCE (X)[6]
EC ALUMINUM[5]	#4	Reference Only	0.533	0.0290
	#2	100-15200-3	0.335	0.0279
	#1/0	100-15400-6	0.211	0.0223
	#3/0	100-15600-9	0.132	0.0251
	#4/0	Reference Only	0.106	0.0266
	336.4 kcmil	100-48100-7	0.0659	0.0251
	556.5 kcmil	100-48200-3	0.0400	0.0267

iii. TRIPLEX UNDERGROUND SECONDARY CABLES [7]

MATERIAL	SIZE	M&S NUMBER	IMPEDANCE - OHMS/100 CIRCUIT FT.[2] IN NON-MAGNETIC DUCT	
			RESISTANCE (R)[1]	REACTANCE (X)[6]
EC AL[5]	#1/0 (75°C)	100-25000-5	0.201	0.0301
	#4/0 (75°C)	100-25300-4	0.101	0.0280
	350 kcmil	100-20700-2	0.0636	0.0275
	750 kcmil	100-21000-3	0.0351	0.0264
	1000 kcmil	100-21200-6	0.0229	0.0258
COPPER	#1/0	110-10105-3	0.1332	0.0432
	#4/0	110-10106-1	0.0664	0.0295
	350 kcmil	110-10107-0	0.0398	0.0275
	500 kcmil	110-10108-8	0.0270	0.0277
	750 kcmil	110-10109-6	0.0199	0.0264

NOTES:

1. Resistance shown in sections i is at 50° C.

   Resistance shown in section ii and iii is at 90° C unless otherwise noted.

   To calculate the resistance at a different temperature, use the following equation; where R_2 is the desired resistance at the temperature t_2.

$$\frac{R_1}{R_2} = \frac{T + t_1}{T + t_2}$$

   T = 234.5 for CU., 228 for AL. t_1, t_2 in °C.

2. $$Impedance, z = \sqrt{R^2 + X^2}$$

3. Kaiser Aluminum, KACS1, 11-63.

4. Resistance: Kaiser Aluminum Electrical Conductor Technical Manual, First Edition, 1954, Table 1, p. 34 & Table 4, p. 40.

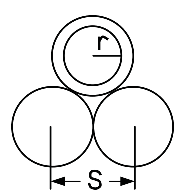
   Reactance: KAC5I

5. Resistance: Aluminum Electrical Conductor Handbook, 1989, Table 9-3, p.9-5

6. Reactance for bundled cables in the configuration shown to the right is calculated using the following formula:

$$X = 2\pi f(0.0153 + 0.1404\log_{10}(s/r))/1000$$

   where X = Inductive reactance to neutral, ohms per 1000 ft.
   s = Spacing between conductors, in.
   r = Radius of metal portion of conductor, in.
   f = frequency, Hz (Use 377 for 2π X 60)

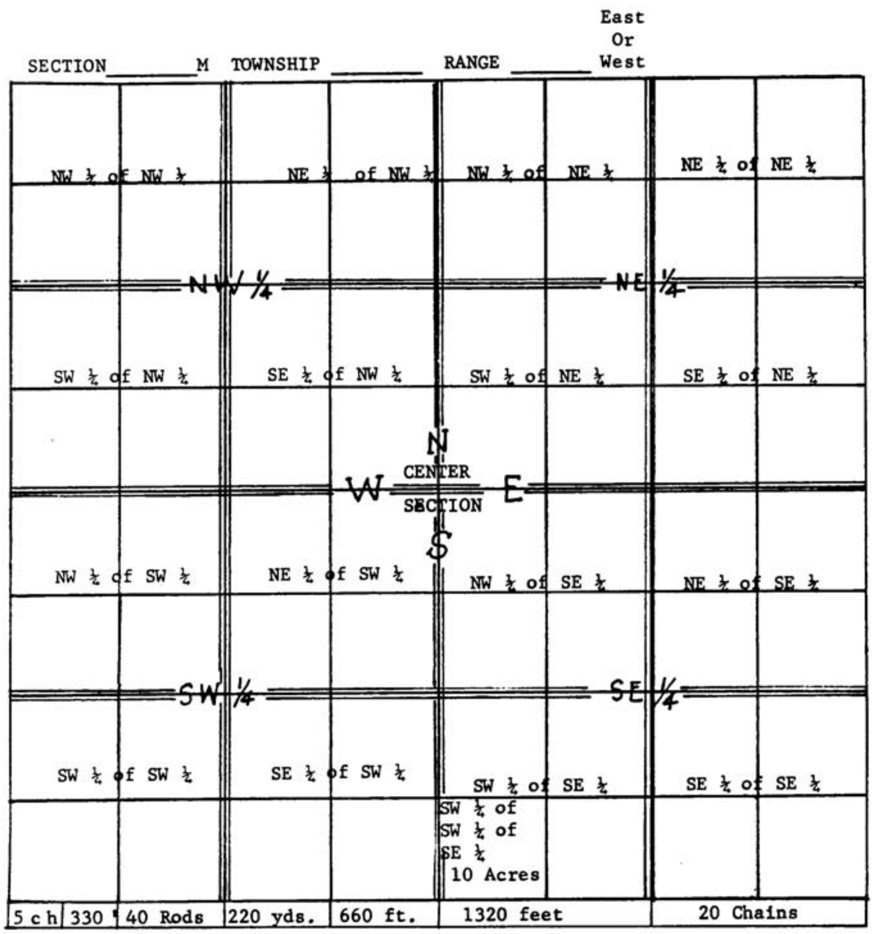


   In section ii and iii, reactance values were calculated using the above formula with conductor diameter and insulation thickness per FPL specifications.

7. For cables in a magnetic duct, increase the Resistance and Reactance values in section iii by 50%.

C. MISCELLANEOUS HELPFUL ITEMS

INDEX TO APPENDIX



1. Sectional Land Division

All Measurements in Government Surveys are indicated by Links and Chains.
One Link = 7.92 inches. One Rod = 16-1/2 ft., 1/4 Chain or 25 Links.
One Chain = 66 ft., 4 Rods or 100 Links. ONe Mile = 5,280 ft., 320 Rods or 80 Chains.
One square Rod contains 272-1/4 sq. ft. One Acre is about 208.75 ft. square.
One acre contains 43,560 sq. ft. or 160 sq. rods. Ten square Chains = One Acre.
A Section of Land is one square Mile and Contains 640 Acres.
A Township Area is 36 square miles and contains 23,040 Acres.

2. Field Survey Check List

a. Poles

1. Size and class, brand, location
2. Test for rot at ground. Look for cracks, rot and woodpecker holes above ground

b. Guys and Anchors

1. Guy size, kind and number (CW or galv.)
2. Anchor size, kind and number
3. Anchor lead length - pace off
4. How and where attached to pole
5. Guard

c. Transformers

1. Size and voltage.

   On 13 kV: replace Trip-o-link fuse switches with 100A fuse switches on all transformers over 25 kVA. Replace Trip-o-link fuse switches on transformers 25 kVA and less if it would not require a pole replacement.

   On 23 kV: Replace all Trip-o-link fuse switches
2. How mounted on pole (quartered, below secondary, etc.)
3. Which phase if more than single phase line

d. Conductors

1. Kind and size
2. Voltage
3. Number of phases
4. How attached to pole (PTP, crossarm, side post, fork, etc.)
5. Span lengths

e. Services

1. Size and kind. If 3 #6CWP, 2 #8 CWP or old copper concentric and must be handled, replace with cable
2. Direction from pole
3. Length if to be replaced

f. Joint Use

1. Owner of attachment (Tel. Co., TV Cable, Fire Alarm, etc.)
2. Type of attachment (cable, drop wire, U.G. riser, etc.)
3. Can proposed work be done and still maintain proper clearance?

g. Clearances

1. 18' minimum over road. (See DCS for other clearances.) If service is low, service pole or secondary spreader bracket. Feasible to raise attachment on pole and/or house?
2. If service pole required, FPL or Telephone to set?

h. Tree Trimming

1. Note size and kind of tree
2. Should they be cut at ground or trimmed
3. Is permit or permission required

i. Land Marks

1. Canals, ditches, swamps
2. Driveways
3. Lot lines (iron pipes, concrete markers, etc.)

j. Unusual Loads

1. Heat pumps or air conditioning units. Check nameplates for size.
2. Stripheat, get kW rating
3. Get house number and meter numbers to determine full and partial services.
4. Look for gas tanks both above ground and buried.
5. Look for gas water heater stacks on house roof.
6. In commercial areas read demand meter and get meter number. Also street number and name.

k. General

Note anything unusual in the area. Take one last look. Too many field notes won't hurt anything and may save extra field trip.

Aircraft landing areas that are observed in the field and are not posted on the primary map should be reported to the Construction Services Rep.

3. Construction Sketch Check List

a. Background

1. Center in drawing area (reserve lower portion of tracing for notes).
2. Use fairly hard pencil, 2H or 3H.
3. Use scale large enough to make sketch easy to ready.
4. Have north arrow pointing either to top or left when practical.

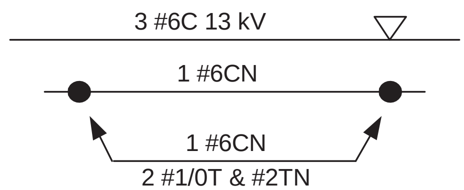
b. Construction Symbols

1. Use standard symbols found in "A" section of Standards. If others must be used, show in a legend what they mean.
2. Use softer pencil for symbols so they stand out, 2H or H.

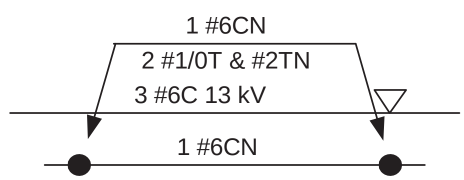
3. If pole is being removed, show all items together -

   30/6 '57 Koppers, 3#7-6' not 30/6'57 3#7-6'
   RM RM RM

4. Place symbols clear of background and each other. Do not cluster together.
5. Don't use common structures just because there are 2 or 3 alike. It makes it harder in case of field changes.
6. Avoid crossing construction symbols with arrows.

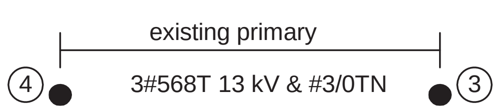


Not Clear



Make sure existing conductors are labeled.

7. When a lot of different conductors are being replaced with all the same size, use general note.



8. Show span distances at secondary position or at right-of-way.

c. Lettering

1. Use same lead as for symbols, 2H or 3H.
2. Use large enough letters so they will be legible.
3. Do not crowd together.

4. Do not letter over background. Erase if necessary.

d. Notes

1. Make sure the following is on the sketch if applicable:
   - Conductor size, type and voltage
   - Phasing of laterals, transformers and devices
   - Poles, size, class, and location numbers
   - Transformers, size, type, phase (indicate dual voltages applicable)
   - Span lengths
   - Anchors and guys, size, type, lead length
   - Tree trimming notes
   - North arrow (up or to the left)
   - Secondary voltage (example 277/480V-WYE)
   - TLM numbers and TLM Model numbers
   - Disconnect switch, and SW number
   - Capacitor, size, phase, switching type code and identification numbers
   - Recloser - size, type, phase, 'R' switch number and by-pass switch number
   - Regulators, size, phase, SW number for bypass
   - Sectionalizer, size, phase, type
   - Primary meter, location number, customer name, CT/PT ratio, meter type, etc.
   - Previous job number if required, or coordinating job number if combination OH/UG job.
   - Phase orientation if not standard
   - Street Light data and Street Light numbers
2. If general construction notes will reduce clutter, use them.

   Examples:
   - All services #1/0 TPX
   - Frame locations ___ per ___
   - Poles ___ through ___ to be set 1' in R/W
3. Put street names on with bolder print than the rest of sketch. Refer to DCS A-7.0.0 for sample construction print.
4. Provide information to enable others to use your sketch. Can the job be found by crews? Can someone else post your job to a primary map?
   - Crew locations - draw a small job site location on sketch or use a marked up primary map.

e. Title Block

1. Fill in all appropriate boxes with an "**X**", not a check mark (√). It is easier to see.
2. Use a short, concise title.
3. Fill in "Pole Line Feet". If none, use -0-.
4. Place above title block "As-Built Required" as applicable or "Survey Crew As-Built Required".
5. Job number must be in title block.

Make a detailed sketch of any pole framing details not shown in Standards. If you feel a detail may be necessary for some other reason - such as a permit drawing for crossing railroad -canal - limited access road, consult your supervisor.

Comments

In general, economics favor a transformer and secondary combination for minimum and moderate customers on average size lots and deluxe customers on small lots. Deluxe customers on large lots, moderate customers on unusually large lots, or unusually large deluxe customers on any size lot are better serviced directly from a transformer. Customer types are defined as follows:

Minimum	-	Full electric in a small home plus one ton of air conditioning.
Moderate	-	Full electric, medium size house and two tons of air conditioning.
Deluxe	-	Full electric in large house with three or more tons of air conditioning.