

2026

ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

Historical Record: 10/23/2026
External Version



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THIS WILL DOWNLOAD THE MANUALS IN THE BACKGROUND, WHICH WILL ENABLE YOU TO EASILY OPEN THE MANUAL IN THE APPROVED PROGRAMS: ACROBAT READER OR BLUEBEAM.

ATTENTION:

- The contents held within this book are for field maintenance only. Every effort should be made, when possible, to upgrade to current standards.

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SUMMARY OF CHANGES

9/20/2024	NEW RELEASE, 6101, 6114, 6201, 6222	5	DMFMO2024v0920.pdf
2/21/2025	5201, 5223	2	DMFMO2025v0221.pdf
8/22/2025	6201, 6242	2	DMFMO2025v0822.pdf
11/21/2025	5401, 5431, 5432	3	DMFMO2025v1121.pdf
5/22/2026	6213	1	DMFMO2026v0522.pdf
7/24/2026	5701, 5745, 6101, 6134, 6136, 6201, 6241	7	DMFMO2026v0724.pdf
8/21/2026	5901, 5931, 6301, 6311, 6312, 6321	6	DMFMO2026v0821.pdf
9/25/2026	6201, 6205	2	DMFMO2026v0925.pdf
10/23/2026	6101, 6112	2	DMFMO2026v1023.pdf

**5000
GENERAL
INFORMATION**

**5000
GENERAL
INFORMATION**

5000 - No FMO standards for this section.

5100
OVERHEAD LAYOUT
SYSTEMS

5100
OVERHEAD LAYOUT
SYSTEMS

5100 - No FMO standards for this section.

**5200
UNDERGROUND
LAYOUT SYSTEMS**

**5200
UNDERGROUND
LAYOUT SYSTEMS**

SUBJECT

5223

SINGLE FAMILY RESIDENTIAL SECONDARY SYSTEMS

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Indicates Latest Revision

Completely Revised

New Page

Information Removed

SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

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UNDERGROUND LAYOUT SYSTEMS

FMO
DM5201

DM5223 FIELD MAINTENANCE ONLY

ALL VERSIONS LISTED IN FMO ARE SUPERSEDED BY THEIR CURRENT VERSION FOUND INSIDE THE ELECTRIC DISTRIBUTION DESIGN MANUAL.

REVISION HISTORY:

02/21/2025: DM5223 MOVED TO FMO

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C							F						
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A	6114 MOVED TO FMO	JIK	KNM	FRC	KRG	02/13/2025	D						

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	SINGLE FAMILY RESIDENTIAL SECONDARY SYSTEMS								

This design standard provides the residential secondary and service system optimum array tables used in conjunction with the General Design Criteria provided in Design Manual 5222. These tables represent an economic analysis of secondary and service system design alternatives, on a cost per lot basis, for approximately 9600 different array possibilities.

The optimum array tables shall be used for residential single-family subdivision design to insure the lowest cost system is installed.

NONE

A. The optimum array tables provide the optimum array configuration, transformer size and secondary/service cable selections based on KW demand, secondary distance, and service distance. The instructions for properly applying the optimum array tables are as follows:

- Determine the KW demand per lot for the subdivision from the Residential Demand Estimating Criteria, Design Manual 5322.

- The secondary footage and structure (Transformer Pad or Handhole) placement is dictated by the lot front footage, street width, and meter location. Typically, the structures will be placed at the load center to serve as many meters as possible from one location. This requires the secondary footage to span from one to four lots or the street width. Therefore, the secondary footage is determined by:

- a. Measuring the distance across the number of lots being spanned or the distance across the street
- b. Adding footage to the overall distance for cable tools (Design Manual 5922). The typical secondary footage for a subdivision should be determined by measuring several lot combinations and using the most common footage(s) as a benchmark for optimum array selections.

- The service distance for a single-sided array service or double-sided array short service is equal to the service panel setback. The double-sided array long service is equal to the service panel setback plus the distance from the originating structure across the street to the property line. The service panel setback is either an estimated or measured distance from behind the sidewalk at the property line to the service panel location. Additional footage shall be added to this distance from the service cable tails (Design Manual 5922).

- Select the subdivision single-sided and/or double-sided optimum array configuration from the table with the appropriate KW demand, secondary and service lengths. The optimum array selection for the subdivision may be used for each individual array whose secondary and service footage does not differ from the typical by more than ten feet. Otherwise, an individual array selection must be made.

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- There are a sufficient number of optimum array tables to address most of the system configurations that will be encountered in residential subdivisions. However, when the required system configuration does not permit selection of an optimum array, consult Design Manual 5222, General Design Procedures Paragraph 7.
- The short service on single and double-sided arrays (Service to the homes on the same side of the street as the transformer) is 2 - #2 and 1 - #4 Al unless a note to the contrary appears below the table.
- Listed below are the double-sided array, long service, and corresponding short service distances.
- The arrays are symmetrical about the transformer unless a note to the contrary is shown.

Double-sided array

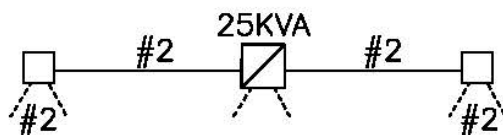
Long Service	Short Service
150'	50'
140'	50'
130'	50'
120'	40'
110'	40'
100'	30'
90'	30'
80'	20'

- The subdivision should now be blocked off in groups of lots corresponding to the number of customers that can be served by the selected optimum array(s):
 - A single-sided and double-sided array combination can be used effectively to serve lots of irregular width or layout (Such as in a cul-de-sac). The combination array must be constructed as shown in Example 3 where the variation can only be used directly off the transformer; not as an extension from any of the handholes.
 - Additional lots may be served from any handhole in an optimum array provided the number of runs connected in the handhole do not exceed the handhole capacity (Presently 6). However, the voltage drop, flicker, and transformer loading limits must be satisfied based on Design Manuals 5431 and 5621.

EXAMPLES

Select the single-sided optimum array for a subdivision having USA cable an average secondary distance of 120' (55' lot fronts, 6' additional for USA cable tails), average service length of 40' (30' service panel setback, 6' additional for USA cable tails), serving 1200 square foot homes with electric water heating.

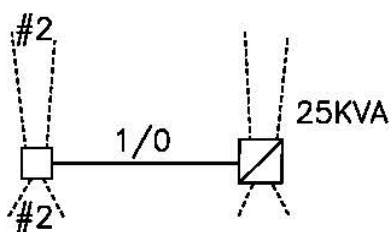
- From the optimum array table on Design Manual 5223.4, the single-sided optimum array for 120' secondary and 40' service serves six customers with a 25 KVA as shown below.



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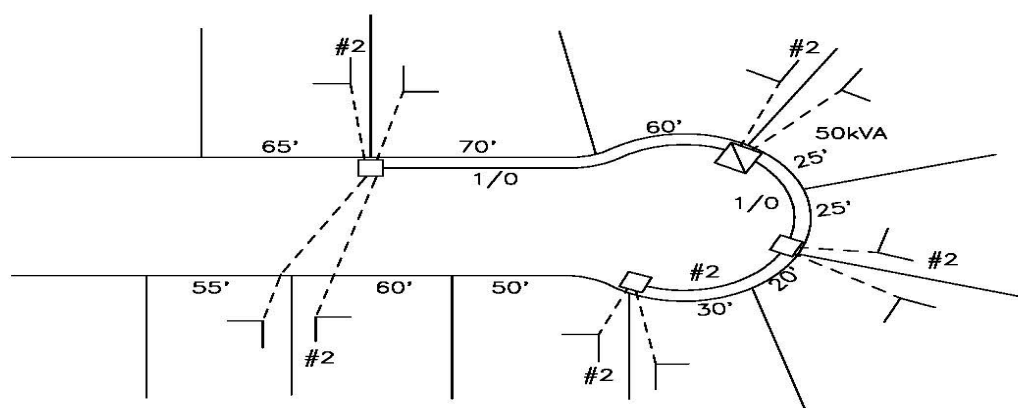
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2. From the optimum array table on Design Manual 5223.4, the double-sided optimum array for this combination serves eight customers with a 25 KVA as shown below.



Select the combination optimum array having 1200 square foot homes with electric water heating (Single-sided and Double-sided) to serve the cul-de-sac shown below. The lot front footages are provided; short-service length is 40', long-service length is 90'.

3. The resulting combination optimum array serves ten customers, 4 double-sided (140' secondary) and six single-sided (60' secondaries). The transformer loading for ten customers is 36 KW. Therefore, a 50 KVA transformer is selected.



REFERENCES

- A. Design Manual 5223 – Residential Distribution System Design
- B. Design Manual 5712 – Secondary Handhole Elimination
- C. Design Manual 5411 – Voltage Drop & Flicker Application Guidelines
- D. Study – “Reduced Secondary and Service System Cost Through Optimum Single-Family Residential Design”, May 1985
- E. Design Manual 5922 – Cable Tail Length Requirements
- F. Design Manual 5322 – Residential Demand Estimating

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Sq. Ft.: 1300-1999 SINGLE-SIDED

4kW Base Load (BL)				6kW Air Conditioning (A/C)				6kW Electric Water Heater (EWH)				5kW Electric Heater(EH)				4kW A/C Option			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2-S3	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
60-80	20-80	25kVA	10	60-70	20-50	1/0-1/0	10	80	20	3/0-1/0-1/0	14	80-80	20-80	1/0-#2	8(a)	80	40-50	1/0-1/0	8(a)(a)
90	20-50	1/0-#2	10	80	20-50	1/0-1/0	10(a)	80	30	3/0-1/0-1/0	12(u)	90-100	20-40	1/0-1/0	8(a)	70	40	1/0-1/0	10
100-110	20-50	1/0-1/0	10	90	20	3/0-1/0	10	80	40-50	3/0-1/0-1/0	12(u)(b)	90-100	50	1/0-1/0	8(a)	25kVA			
120	50	1/0-1/0	10	90	30-50	3/0-1/0	10(a)	70	20-90	3/0-3/0-3/0	12(v)	110	20	#2	6	80	20-30	1/0-1/0	8(a)(a)
120	20-40	#2	6	100	20	3/0-3/0	10	25kVA				110	30-80	3/0-1/0	8(a)	70	20-30	3/0-1/0	8(a)
130-150	20-80	#2	8	100	30-50	3/0-3/0	10(a)	80-120	20-50	#2	6	120	20-40	#2	6	70	40-50	3/0-1/0	8(a)(a)
				110	20-50	3/0-3/0	10(a)	130	20-40	#2	6	120	50	3/0-1/0	8(a)	80	20	3/0-1/0	8(a)
				120	20-40	3/0-3/0	8(t)	130	50	1/0	6	130-150	20-50	#2	6	80	30-40	3/0-1/0	8(t)(f)
				120	50	3/0-3/0	8(a)	140-150	20-50	1/0	6					80	50	1/0	8
				25kVA												90	20-50	1/0	6
				130	20-40	1/0	6									100	20-40	1/0	6
				130	50	1/0	6									100	50	1/0	6(f)
				140-150	20-40	1/0	8									110	20-30	1/0	6
				140-150	50	1/0	6(f)									110	40-50	1/0	6(f)
																120	20-30	1/0	6
																120	40	1/0	6(f)
																120	50	3/0	6
																130	20	1/0	6
																130	30	1/0	6(f)
																130	40-50	3/0	8
																140	20	1/0	6(f)
																140	30-50	3/0	6
																150	20	1/0	6(f)
																150	30-40	3/0	6
																150	50	3/0	6(f)

a)H2=1/0, b)H3=1/0, c)H1=1/0, d)H4=1/0, e)H2-H5=1/0-1/0, f)H1-H4=1/0-1/0, g)H2-H4=1/0-1/0
h)H3-H6=1/0-1/0, i)H3-H5=1/0-1/0, j)H2=3/0, k)H3-H5=3/0-1/0, m)H2-H4=1/0-3/0, n)H1-H4=3/0-3/0
o)H2-H5=3/0-3/0, p)H2-H4=3/0-3/0, q)H1-H2-H4=1/0-1/0-1/0, r)H1=3/0
s)S4=#2, t)S4=1/0, u)S4-S5=1/0-#2, v)S4-S5=1/0-1/0, w)S2-S4=3/0-1/0, x)S4=3/0

DOUBLE-SIDED

4kW Base Load (BL)				6kW Air Conditioning (A/C)				6kW Electric Water Heater (EWH)				5kW Electric Heater(EH)				4kW A/C Option			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
60	80-150	1/0-1/0	20	60	80-100	3/0-3/0	18(a)(t)	60	80-110	3/0-3/0	20	80	80-150	3/0-1/0	20	80	80	3/0-1/0	20
70-80	80-150	3/0-1/0	20	60	110-150	3/0-3/0	18(a)(t)	60	120-150	3/0-3/0	20(a)	70	80-150	3/0-1/0	20(a)	80	90-120	3/0-1/0	20(a)
90	80-140	3/0-1/0	20	70	80-100	1/0	12	70	80	3/0-3/0	20	80	80-110	3/0-3/0	20	80	130-140	3/0-3/0	20(a)
				70	110-150	350-3/0	18(a)(t)	70	90-100	3/0-3/0	20(a)	80	120	3/0-3/0	18(f)	80	150	3/0-3/0	20(a)
90	150	#2	8	80	80-90	1/0	12	70	110	1/0	12	90	80	3/0-3/0	20(a)	70	80-120	3/0-1/0	20(a)
100	80-150	#2	8	80	100-130	350-3/0	18(a)(t)	80	80-100	3/0-3/0	20(a)					70	130	3/0-3/0	20(a)
110	80-130	#2	8	80	140-150	3/0	12(f)	80	110	1/0	12	80	130-150	1/0	8	70	140-150	3/0-3/0	20(a)
110	140-150	1/0	8	90	80-90	1/0	12									80	80-100	3/0-1/0	20(a)
120	80-90	#2	8	90	100-150	1/0	12(f)	70	120-150	1/0	12	100-110	80-150	1/0	8	80	110-130	3/0-3/0	20(a)
120	100-150	1/0	8	100	80	1/0	12	80	120-140	1/0	12	120	80-130	1/0	8	80	140-150	3/0-3/0	20(a)
130-150	80-150	1/0	8	100	90-130	1/0	12(f)	80	150	1/0	12(a)	120	140-150	1/0	8(c)	90	80-120	3/0-1/0	20(a)
120	100-150	1/0	8	100	140-150	3/0	12(f)	90	80-120	1/0	12	130	80-100	1/0	8	90	140-150	3/0-3/0	20(a)
130-150	80-150	1/0	8	110	80-130	1/0	12(f)	90	130-150	1/0	12(f)	130	110-150	1/0	8(c)	100	80	3/0-1/0	20(a)
				110	140-150	3/0	12(f)	100	80-110	1/0	12	140	80-80	1/0	8	100	90-110	3/0-3/0	20(a)
				120	80-110	1/0	12(f)	100	120-150	1/0	12(f)	140	100-150	1/0	8(c)	100	140-150	3/0-3/0	20(a)
				120	120-140	3/0	12(f)	110	80	1/0	12	150	80-120	1/0	8(c)				
				120	150	3/0	12(n)	110	90-150	1/0	12(f)		130-150	3/0	8	90	130	3/0-3/0	18(t)(w)
				130	80-90	3/0	12	120	80-120	1/0	12(f)					100	120	3/0-3/0	18(t)(w)
				130	100-130	3/0	12(f)	120	130-150	3/0	12					100	130	3/0-3/0	18(w)
				130	140-150	3/0	12(n)	130	80	1/0	12(f)					110	80-90	1/0	12(f)
				140	80-90	3/0	12	130	90-140	3/0	12					110	100-150	3/0	12(f)
				140	100-130	3/0	12(f)	130	150	3/0	12(f)					120	80-90	1/0	12(f)
				140	140-150	3/0	12(n)	140	80-120	3/0	12					120	100-130	3/0	12(f)
				150	80-90	3/0	12	140	130-150	3/0	12(f)					120	140-150	3/0	12(n)
				150	100-120	3/0	12(f)	150	80-110	3/0	12					130	80-90	1/0	12(f)
				150	130-150	3/0	12(n)	150	120-150	3/0	12(f)					130	100-130	3/0	12(f)
																130	140-150	3/0	12(n)
																140	80-120	3/0	12(f)
																140	130-150	3/0	12(n)
																150	80-120	3/0	12(f)

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Sq. Ft.: 0-299

Sq. Ft.: 1300-1999

H1-H4 SHORT=1/0-1/0

Sq. Ft.: 2000-2999

SINGLE-SIDED

6.5kW EH & EWH				6kW A/C & EWH				7.5kW EH & EWH				7kW A/C & EWH			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
50kVA				50kVA				50kVA				75kVA			
60	30	3/0-3/0-1/0	14	60-70	20-50	1/0-1/0	10	60	30	3/0-1/0	10	60	20	3/0-1/0	10
70	30-50	1/0-1/0	10	80	20-50	1/0-1/0	10(a)	60	40-50	1/0-1/0	10(a)	60	20-50	3/0-3/0	10
80	20-50	1/0-1/0	10	90	20	3/0-1/0	10	70	20-50	3/0-1/0	10	70	20-50	3/0-3/0	10
80	20	3/0-1/0	10	90	30-50	3/0-1/0	10(a)	80-90	20-50	3/0-3/0	10	80	20-40	3/0-3/0	10(a)
25kVA				25kVA				25kVA				25kVA			
80	30-50	#2	6	100	20	3/0-3/0	10	100	20	3/0-3/0	10	80	20-30	3/0-3/0	10
90-110	20-50	#2	6	100	30-50	3/0-3/0	10(a)	100	30-50	3/0-3/0	10(a)	80	40	3/0-3/0	10(a)
120-150	20-50	1/0	6	110	20-50	3/0-3/0	10(a)	110	20	3/0-3/0	10(a)	90	50	3/0-3/0	10(a)
				120	20-40	3/0-3/0	8(a)	110	50	3/0-3/0	8(a)	100	20	3/0-3/0	10(a)
				120	50	3/0-3/0	8(a)	120-150	20-50	1/0	6	100	30-40	3/0-3/0	10(a)
				25kVA				25kVA				50kVA			
				130	20-40	1/0	6					110	20-40	1/0	6
				130	50	1/0	6					120	20-30	1/0	6
				140-150	20-40	1/0	6					120	40	1/0	6
				140-150	50	1/0	8(f)					130	20-30	1/0	6
												130	40	1/0	6
												130	50	3/0	6
												140	20-30	1/0	6
												140	40-50	3/0	6
												150	20-40	3/0	6
												150	50	3/0	8(f)

SINGLE-SIDED

6.5kW EH & EWH				6kW A/C & EWH				7.5kW EH & EWH				7kW A/C & EWH			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
50kVA				50kVA				50kVA				75kVA			
60	30	3/0-3/0-1/0	14	60-70	20-50	1/0-1/0	10	60	30	3/0-1/0	10	60	20	3/0-1/0	10
70	30-50	1/0-1/0	10	80	20-50	1/0-1/0	10(a)	60	40-50	1/0-1/0	10(a)	60	20-50	3/0-3/0	10
80	20-50	1/0-1/0	10	90	20	3/0-1/0	10	70	20-50	3/0-1/0	10	70	20-50	3/0-3/0	10
80	20	3/0-1/0	10	90	30-50	3/0-1/0	10(a)	80-90	20-50	3/0-3/0	10	80	20-40	3/0-3/0	10(a)
25kVA				25kVA				25kVA				25kVA			
80	30-50	#2	6	100	20	3/0-3/0	10	100	20	3/0-3/0	10	80	20-30	3/0-3/0	10
90-110	20-50	#2	6	100	30-50	3/0-3/0	10(a)	100	30-50	3/0-3/0	10(a)	80	40	3/0-3/0	10(a)
120-150	20-50	1/0	6	110	20-50	3/0-3/0	10(a)	110	20	3/0-3/0	10(a)	90	50	3/0-3/0	10(a)
				120	20-40	3/0-3/0	8(a)	110	50	3/0-3/0	8(a)	100	20	3/0-3/0	10(a)
				120	50	3/0-3/0	8(a)	120-150	20-50	1/0	6	100	30-40	3/0-3/0	10(a)
				25kVA				25kVA				50kVA			
				130	20-40	1/0	6					110	20-40	1/0	6
				130	50	1/0	6					120	20-30	1/0	6
				140-150	20-40	1/0	6					120	40	1/0	6
				140-150	50	1/0	8(f)					130	20-30	1/0	6
												130	40	1/0	6
												130	50	3/0	6
												140	20-30	1/0	6
												140	40-50	3/0	6
												150	20-40	3/0	6
												150	50	3/0	8(f)

SINGLE-SIDED

6.5kW EH & EWH				6kW A/C & EWH				7.5kW EH & EWH				7kW A/C & EWH			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
50kVA				50kVA				50kVA				75kVA			
60	30	3/0-3/0-1/0	14	60-70	20-50	1/0-1/0	10	60	30	3/0-1/0	10	60	20	3/0-1/0	10
70	30-50	1/0-1/0	10	80	20-50	1/0-1/0	10(a)	60	40-50	1/0-1/0	10(a)	60	20-50	3/0-3/0	10
80	20-50	1/0-1/0	10	90	20	3/0-1/0	10	70	20-50	3/0-1/0	10	70	20-50	3/0-3/0	10
80	20	3/0-1/0	10	90	30-50	3/0-1/0	10(a)	80-90	20-50	3/0-3/0	10	80	20-40	3/0-3/0	10(a)
25kVA				25kVA				25kVA				25kVA			
80	30-50	#2	6	100	20	3/0-3/0	10	100	20	3/0-3/0	10	80	20-30	3/0-3/0	10
90-110	20-50	#2	6	100	30-50	3/0-3/0	10(a)	100	30-50	3/0-3/0	10(a)	80	40	3/0-3/0	10(a)
120-150	20-50	1/0	6	110	20-50	3/0-3/0	10(a)	110	20	3/0-3/0	10(a)	90	50	3/0-3/0	10(a)
				120	20-40	3/0-3/0	8(a)	110	50	3/0-3/0	8(a)	100	20	3/0-3/0	10(a)
				120	50	3/0-3/0	8(a)	120-150	20-50	1/0	6	100	30-40	3/0-3/0	10(a)
				25kVA				25kVA				50kVA			
				130	20-40	1/0	6					110	20-40	1/0	6
				130	50	1/0	6					120	20-30	1/0	6
				140-150	20-40	1/0	6					120	40	1/0	6
				140-150	50	1/0	8(f)					130	20-30	1/0	6
												130	40	1/0	6
												130	50	3/0	6
												140	20-30	1/0	6
												140	40-50	3/0	6
												150	20-40	3/0	6
												150	50	3/0	8(f)

DOUBLE-SIDED				DOUBLE-SIDED				DOUBLE-SIDED				DOUBLE-SIDED											
6.5kW EH & EWH				6kW A/C & EWH				7.5kW EH & EWH				7kW A/C & EWH				8kW EH & EWH				8kW A/C & EWH			
Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust	Sec Ft	Serv Ft	S1-S2	# Cust
75kVA				75kVA				75kVA				100kVA				75kVA				75kVA			
60	80-90	3/0-3/0	20	60	80-100	3/0-3/0	16(a)(f)	60	80-100	3/0-3/0	16(f)(a)	60	150	350-3/0	16(a)(f)	60	80-100	3/0-3/0	16(f)(a)	60	80-100	3/0-3/0	12(f)
70	80-100	3/0-3/0	20(a)	70	80-100	3/0-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	150	350-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	100-140	3/0-3/0	12(f)
70	80-100	3/0-3/0	20(a)	70	80-100	3/0-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	150	350-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	100-140	3/0-3/0	12(f)
50kVA				50kVA				50kVA				50kVA				50kVA				50kVA			
70	110-150	3/0-3/0	12	70	110-150	3/0-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	150	350-3/0	16(a)(f)	70	100-120	3/0-3/0	16(f)(a)	70	100-140	3/0-3/0	12(f)
80	80-110	1/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	120-150	1/0	12(f)	80	140-150	3/0	12(f)	80	80-110	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-150	350-3/0	16(f)(a)	80	150	350-3/0	16(f)(a)	80	100-120	3/0-3/0	16(f)(a)	80	100-140	3/0-3/0	12(f)
80	80-100	3/0	12	80	100-130	350-3/0	16(f)(a)	80	100-15														

**5300
DEMAND
ESTIMATING**

**5300
DEMAND
ESTIMATING**

5300 - No FMO standards for this section.

5400

VOLTAGE DROP

5400

VOLTAGE DROP

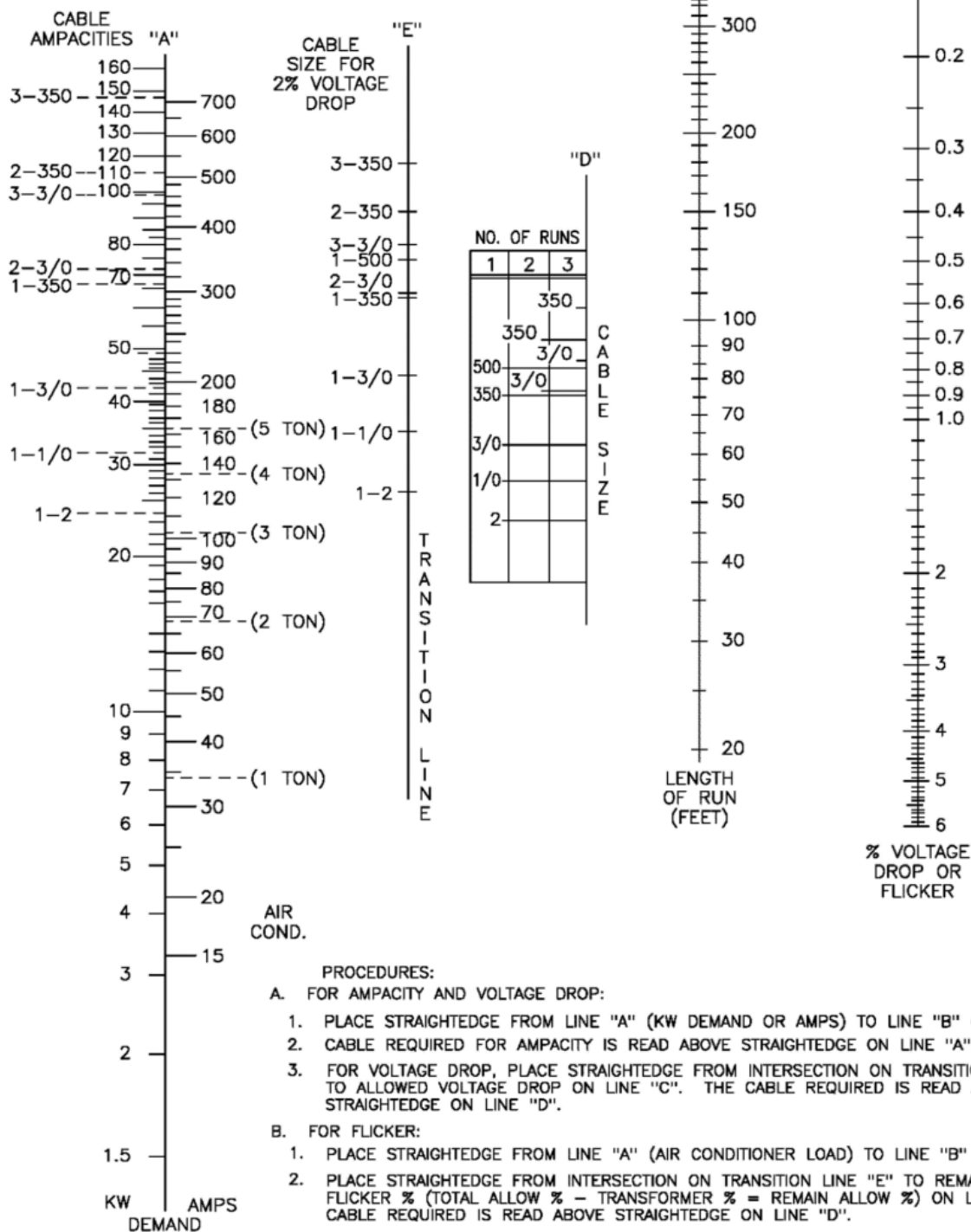
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	UNDERGROUND VOLTAGE DROP AND FLICKER NOMOGRAPH					

SEE GENERAL NOTES ON PAGE 5413.3 IF THE % FLICKER IS GREATER THAN ALLOWABLE LIMITS.



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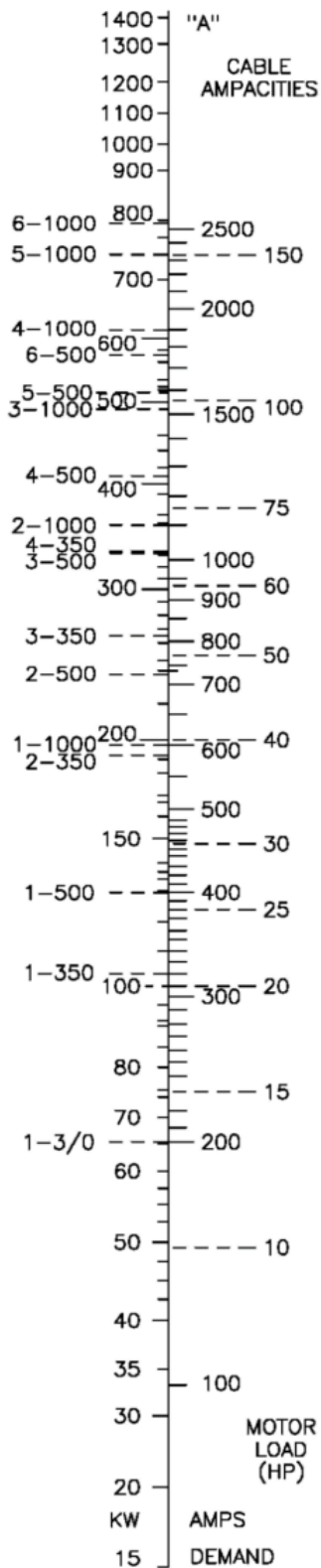
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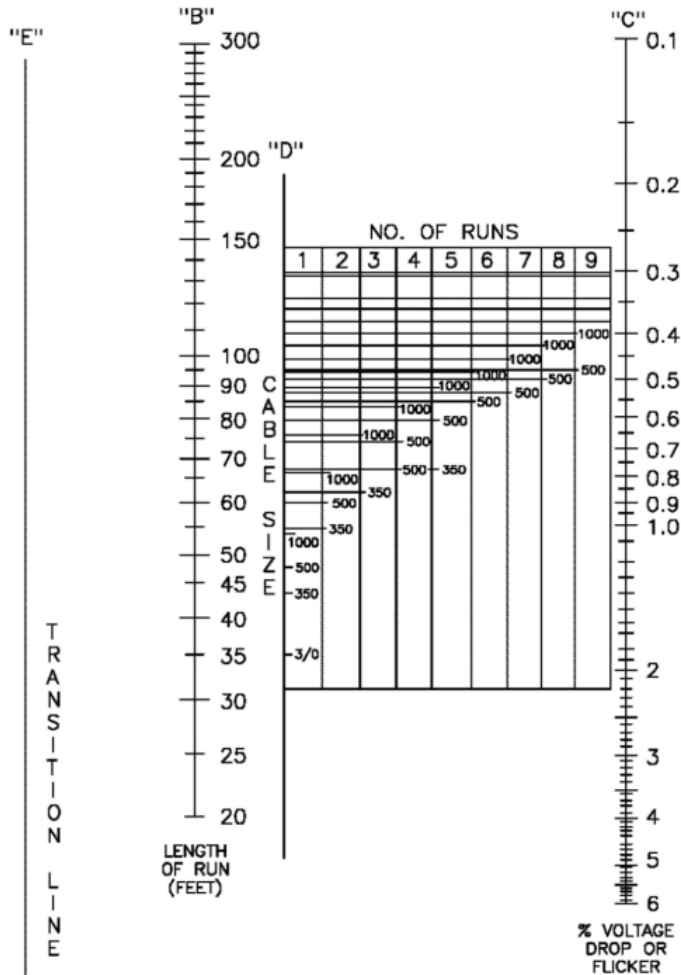
SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

SINGLE-PHASE 120/240V UNDERGROUND VOLTAGE DROP
AND FLICKER NOMOGRAPH

FMO
DM5431.1



SEE GENERAL NOTES ON PAGE 5413.3 IF THE % FLICKER IS GREATER THAN ALLOWABLE LIMITS.



- PROCEDURES:
- A. FOR AMPACITY AND VOLTAGE DROP:
1. PLACE STRAIGHTEDGE FROM LINE "A" (KW DEMAND OR AMPS) TO LINE "B" (LENGTH OF RUN).
 2. CABLE REQUIRED FOR AMPACITY IS READ ABOVE STRAIGHTEDGE ON LINE "A"
 3. FOR VOLTAGE DROP, PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO ALLOWED VOLTAGE DROP ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".
- B. FOR FLICKER:
1. PLACE STRAIGHTEDGE FROM LINE "A" (MOTOR LOAD) TO LINE "B" (LENGTH OF RUN).
 2. PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO REMAINING ALLOWABLE FLICKER % (TOTAL ALLOW % - TRANSFORMER % = REMAIN ALLOW %) ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".

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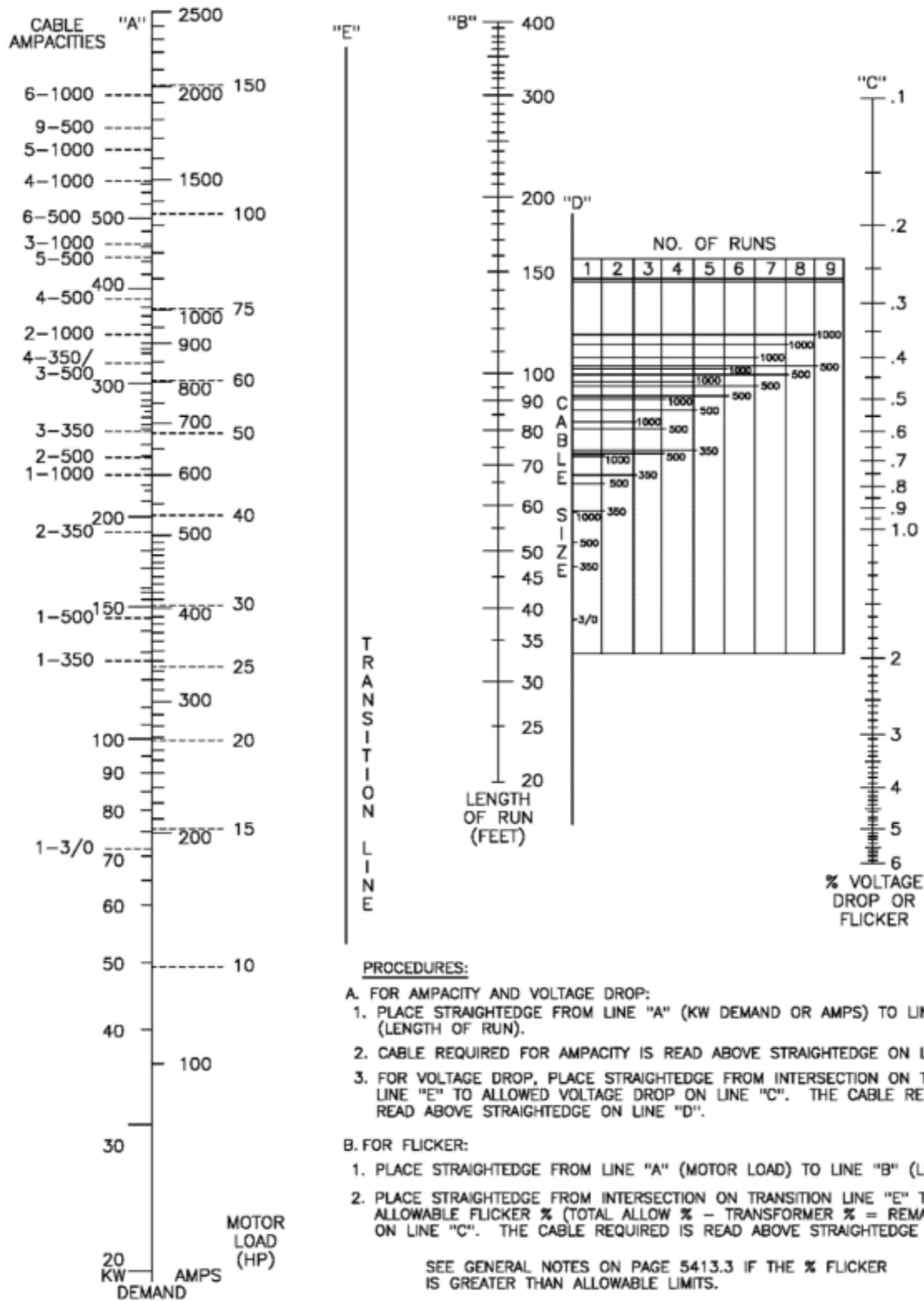
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3Ø 120/208Y UNDERGROUND VOLTAGE DROP
AND FLICKER NOMOGRAPH

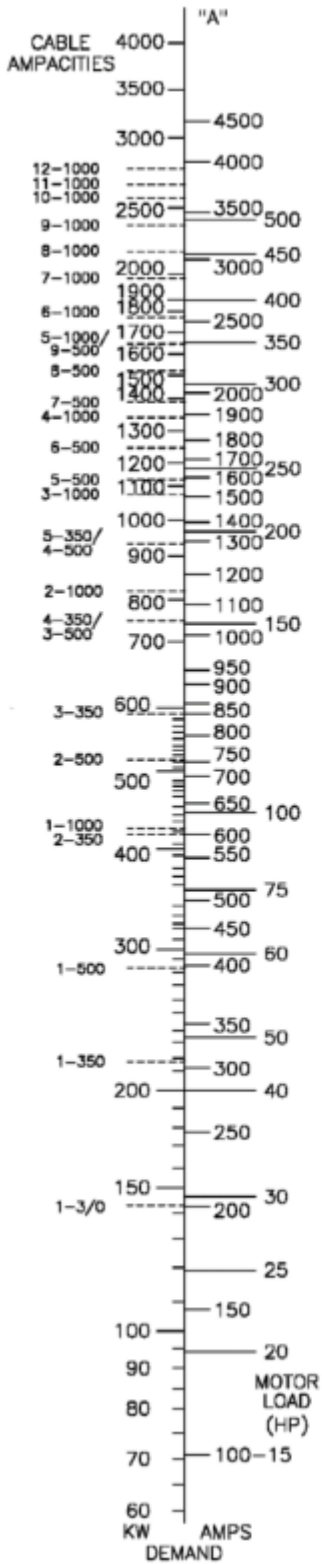
FMO
DM5431.2



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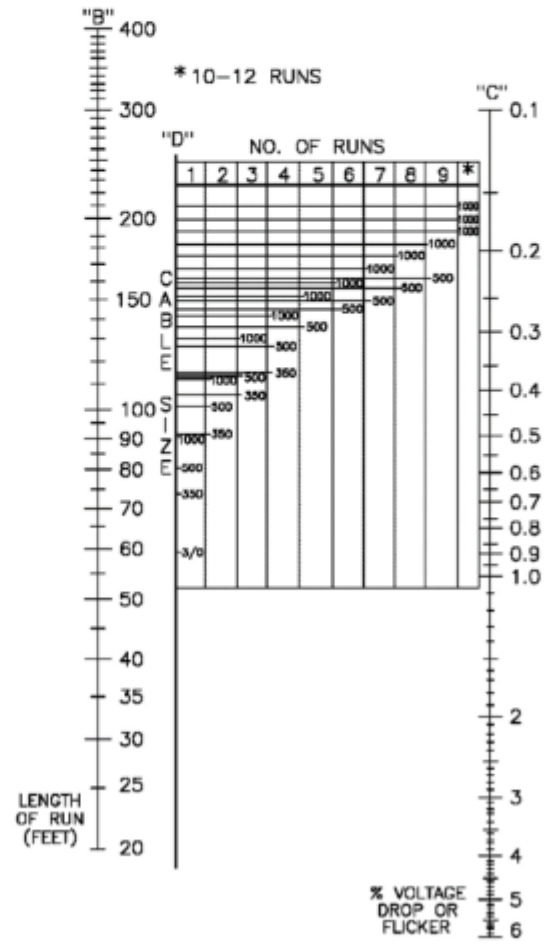
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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY					
	3Ø 120/240V UNDERGROUND VOLTAGE DROP AND FLICKER NOMOGRAPH					



- PROCEDURES:
- A. FOR AMPACITY AND VOLTAGE DROP:
1. PLACE STRAIGHTEDGE FROM LINE "A" (KW DEMAND OR AMPS) TO LINE "B" (LENGTH OF RUN).
 2. (LENGTH OF RUN).
 3. CABLE REQUIRED FOR AMPACITY IS READ ABOVE STRAIGHTEDGE ON LINE "A" FOR VOLTAGE DROP, PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO ALLOWED VOLTAGE DROP ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".
- B. FOR FLICKER:
1. PLACE STRAIGHTEDGE FROM LINE "A" (MOTOR LOAD) TO LINE "B" (LENGTH OF RUN).
 2. PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO REMAINING ALLOWABLE FLICKER % (TOTAL ALLOW % - TRANSFORMER % = REMAIN ALLOW %) ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".

SEE GENERAL NOTES ON PAGE 5413.3 IF THE % FLICKER IS GREATER THAN ALLOWABLE LIMITS.



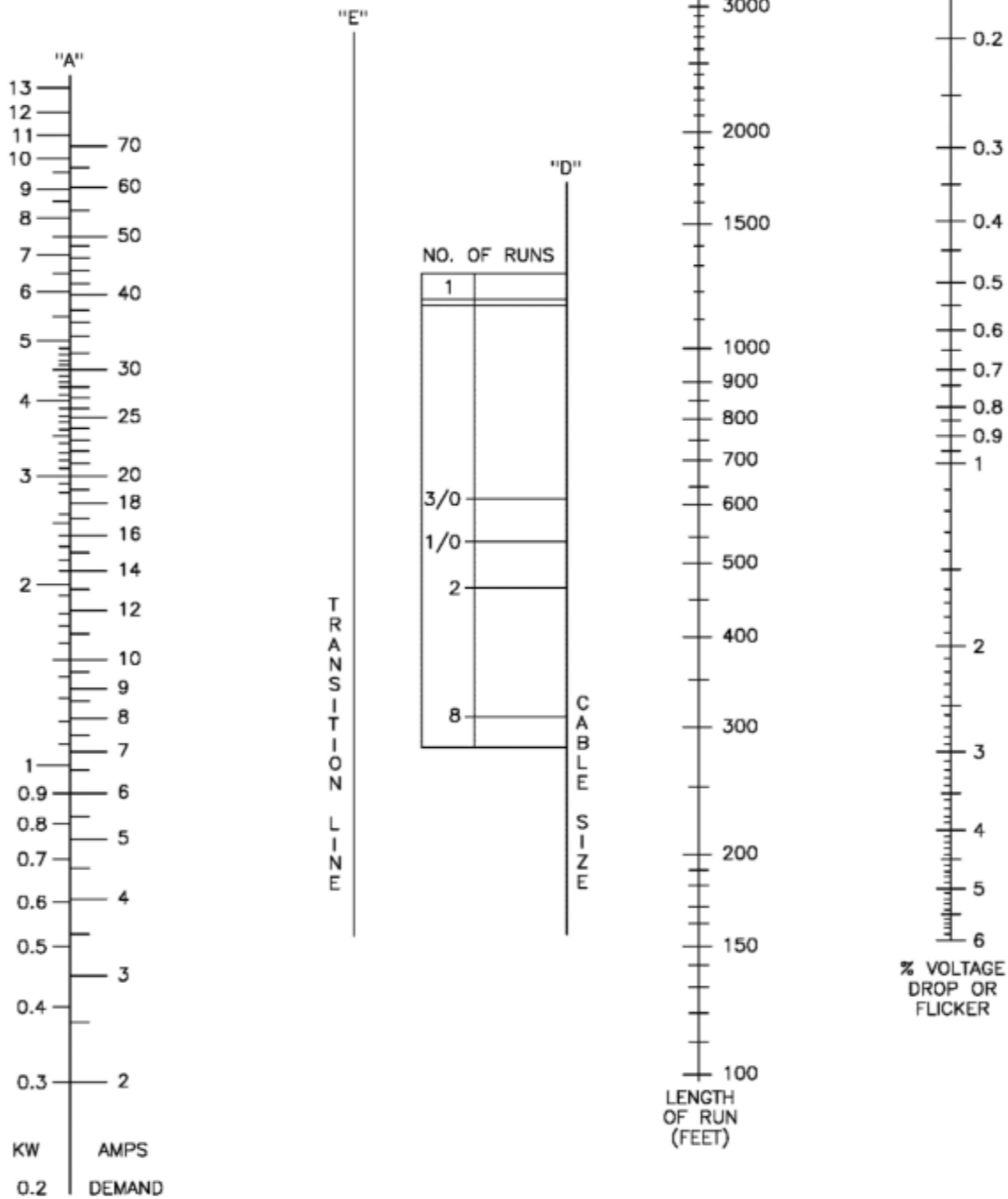
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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY					
	3Ø 277/480Y UNDERGROUND NOMOGRAPH					

PROCEDURES:

PLACE STRAIGHTEDGE FROM KW DEMAND OR AMPS (LINE "A") TO LENGTH OF RUN (LINE "B"). THEN FROM THE TRANSITION POINT (LINE "E") TO THE SIZE OF CABLE (LINE "D"). READ THE % VOLTAGE DROP (LINE "C") FOR THAT SEGMENT OF CABLE.



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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

SINGLE-PHASE 120/240V UNDERGROUND
STREET LIGHT NOMOGRAPH

FMO
DM5431.5

ALL VERSIONS LISTED IN FMO ARE SUPERSEDED BY THEIR CURRENT VERSION FOUND INSIDE THE ELECTRIC DISTRIBUTION DESIGN MANUAL.

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		SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY												
		OVERHEAD VOLTAGE DROP AND FLICKER NOMOGRAPH												

PROCEDURES:

A. FOR AMPACITY AND VOLTAGE DROP:

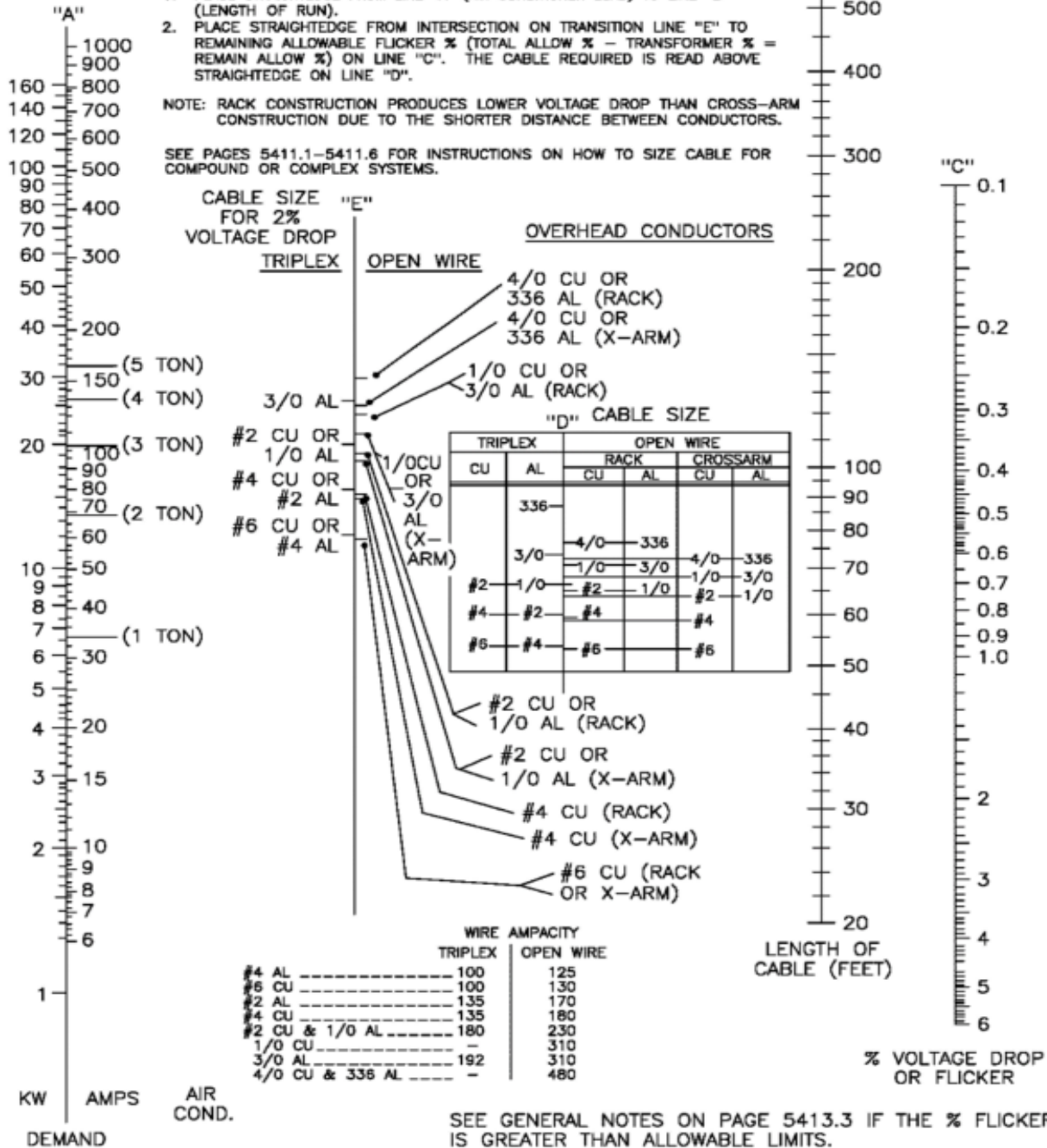
1. PLACE STRAIGHTEDGE FROM LINE "A" (KW DEMAND OR AMPS) TO LINE "B" (LENGTH OF RUN).
2. WIRE REQUIRED FOR AMPACITY IS READ OFF TABLE BELOW.
3. FOR VOLTAGE DROP, PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO ALLOWED VOLTAGE DROP ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".

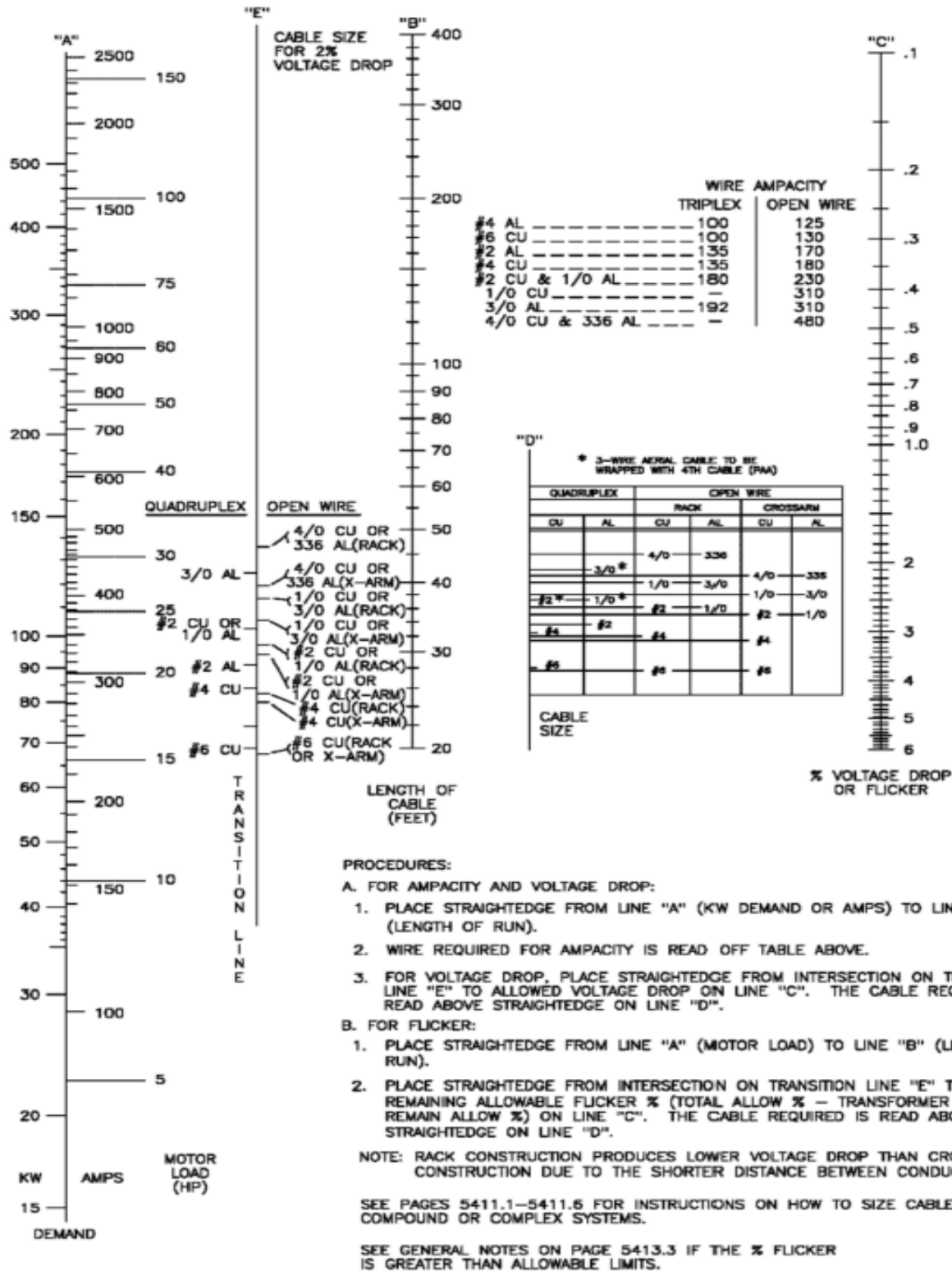
B. FOR FLICKER:

1. PLACE STRAIGHTEDGE FROM LINE "A" (AIR CONDITIONER LOAD) TO LINE "B" (LENGTH OF RUN).
2. PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO REMAINING ALLOWABLE FLICKER % (TOTAL ALLOW % - TRANSFORMER % = REMAIN ALLOW %) ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE ON LINE "D".

NOTE: RACK CONSTRUCTION PRODUCES LOWER VOLTAGE DROP THAN CROSS-ARM CONSTRUCTION DUE TO THE SHORTER DISTANCE BETWEEN CONDUCTORS.

SEE PAGES 5411.1-5411.6 FOR INSTRUCTIONS ON HOW TO SIZE CABLE FOR COMPOUND OR COMPLEX SYSTEMS.





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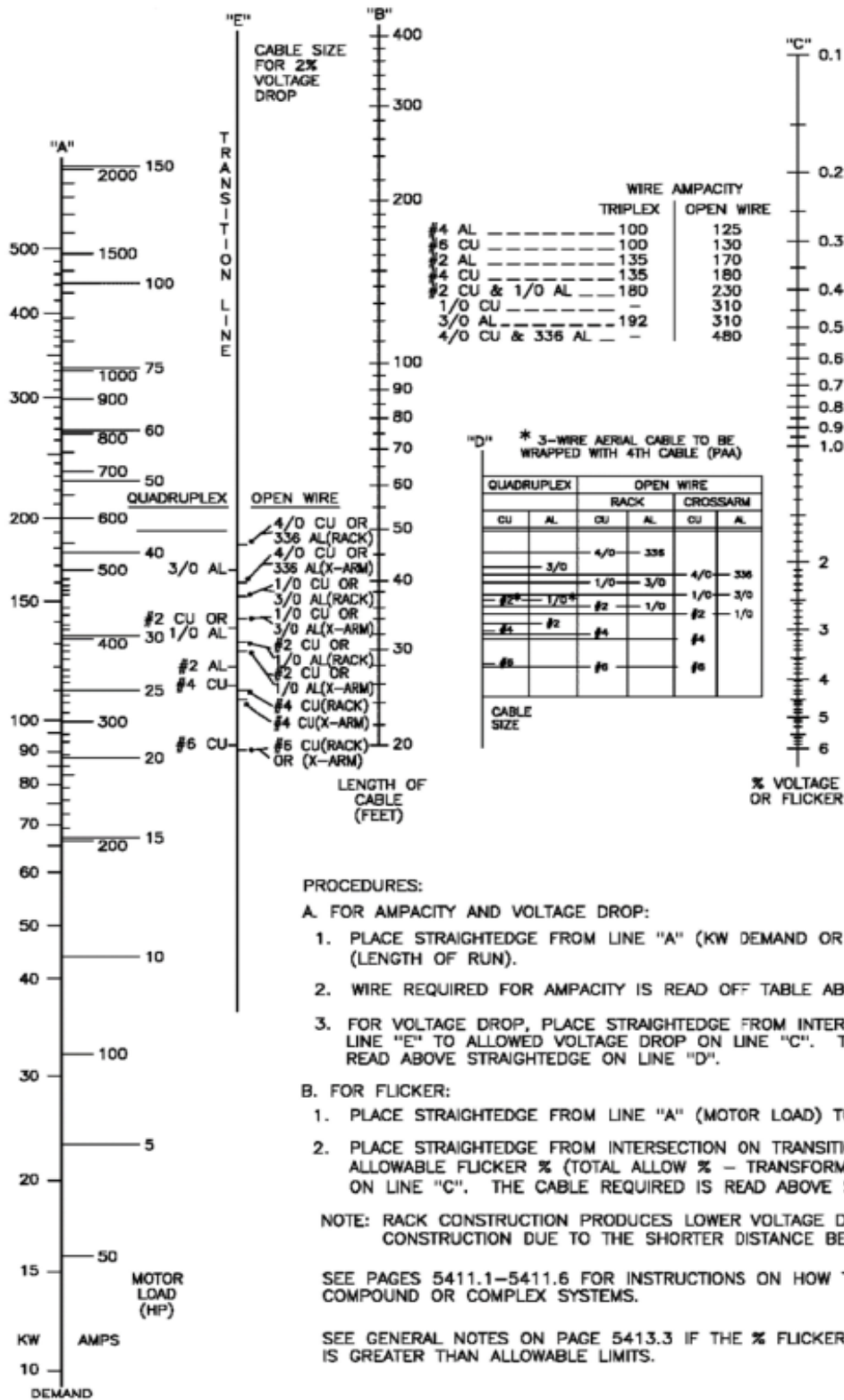
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THREE PHASE 120/208Y OVERHEAD VOLTAGE DROP
AND FLICKER NOMOGRAPH

FMO
DM5432.2



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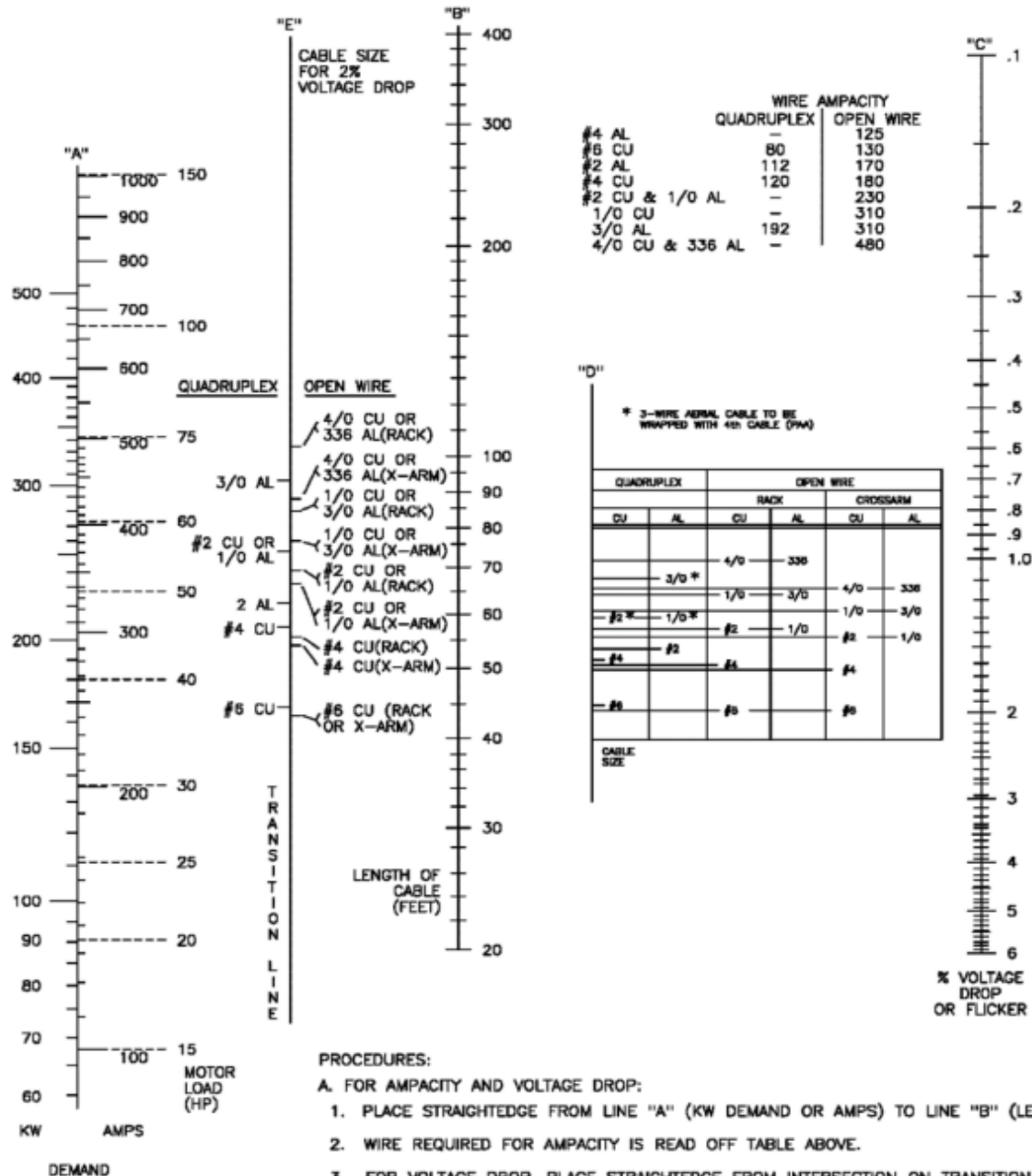
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THREE PHASE 120/240V OVERHEAD VOLTAGE DROP
AND FLICKER NOMOGRAPH

FMO
DM5432.3



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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

**THREE PHASE 480 OVERHEAD VOLTAGE DROP
AND FLICKER NOMOGRAPH**

**FMO
DM5432.4**

5500
CONDUCTOR
AMPACITIES

**5500
CONDUCTOR
AMPACITIES**

5500 - No FMO standards for this section.

5600

TRANSFORMERS

5600

TRANSFORMERS

5600 - No FMO standards for this section.

**5700
PADS &
SUBSTRUCTURES**

**5700
PADS &
SUBSTRUCTURES**

SUBJECT

5745

ELECTRIC VAULT DESIGN TABLES FOR SDG&E INTERNAL USE

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SUBSTRUCTURES AND CONDUIT

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DM5701.1

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07/22/2026: DM5745 TABLES MOVED TO FMO

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A	5745 TABLES MOVED TO FMO	YZZ	FRC	FRC	FRC	07/22/2026	D						

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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY					
	ELECTRIC VAULT DESIGN TABLES FOR SDG&E INTERNAL USE					

24.6. The following tables apply only to existing or legacy vaults. All new vault installations shall comply with DM5745, which requires a minimum floor-to-ceiling height of 12 feet.

24.6.1. Below grade single transformer vault requirements for 120/208V.

CUST. BOARD	208V TRANSF. SIZE	FRONT TO BACK*	WALL TO WALL	ALONG W/ TRANSF. SWITCH INSTALLED ON SIDE WALL.		ALONG W/ TRANSF. SWITCH INSTALLED ON END WALL		FLOOR TO CEILING	CEILING EQUIPMENT	TRANSF.	SUMP
SIZE	(KVA)	L LENGTH	W WIDTH	L LENGTH	W WIDTH	L LENGTH	W WIDTH	HEIGHT	OPENING	WEIGHT	CAP.
200	75	13' - 6"	9' - 6"	NA	NA	NA	NA	8' - 0"	4' - 6" X 6' - 6"	3,500	240
400	150	13' - 6"	9' - 6"	NA	NA	NA	NA	8' - 0"	4' - 6" X 6' - 6"	3,900	240
600	225	14' - 0"	9' - 6"	NA	NA	NA	NA	8' - 0"	5' - 0" X 6' - 6"	4,200	240
800	300	15' - 0"	10' - 6"	NA	NA	NA	NA	8' - 6"	6' - 0" X 7' - 6"	5,000	255
1000	300	15' - 0"	10' - 6"	NA	NA	NA	NA	8' - 6"	6' - 0" X 7' - 6"	5,000	255
1200	500	16' - 6"	12' - 6"	21' - 6"	15' - 0"	19' - 6"	20' - 9" *	9' - 0"	6' - 6" X 7' - 6"	6,600	290
1600	500	16' - 6"	12' - 6"	21' - 6"	15' - 0"	19' - 6"	20' - 0" *	9' - 0"	6' - 6" X 7' - 6"	6,600	290
2000	750	17' - 0"	12' - 6"	22' - 6"	15' - 0"	20' - 0"	20' - 0" *	9' - 0"	7' - 0" X 7' - 6"	7,550	425
2500	1000	18' - 0"	13' - 6"	23' - 6"	16' - 6"	21' - 6"	20' - 0" *	10' - 0"	8' - 0" X 7' - 6"	8,200	435
3000	1000	18' - 0"	13' - 6"	23' - 6"	16' - 6"	21' - 6"	20' - 0" *	10' - 0"	8' - 0" X 7' - 6"	8,200	435
4000	1000 1500**	20' - 0"	16' - 0"	25' - 6"	19' - 0"	23' - 0"	20' - 0"	11' - 0"	10' - 0" X 9' - 0"	10,150	515

24.6.2. Below grade multiple transformer installation 120/208 side by side minimum vault dimensions for multi-services.

LENGTH	13'-6"	13'-6"	14'-0"	15'-0"	15'-0"	16'-6"	16'-6"	17'-0"	18'-0"	18'-0"	20'-0"
-	200i	400i	600i	800i	1000i	1200i	1600i	2000i	2500i	3000i	4000i
WIDTH "A"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	13'-6"	16'-0"
WIDTH "B"	7'-6"	7'-6"	7'-6"	8'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"

WIDTH "A" = Minimum vault requirements for one service panel according to main size

WIDTH "B" = Additional vault requirements for each added service main

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B	EDITORIAL CHANGES	YZZ	JES	FRC	JJP	10/31/2025	E						
A	ORIGINAL ISSUE	-	-	-	-	11/20/2018	D	5745 TABLES MOVED TO FMO	YZZ	FRC	FRC	FRC	07/22/2026

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SDG&E ELECTRIC VAULT REQUIREMENTS AND SPECIFICATIONS

FMO
DM5745.1

24.6.3. Below grade minimum electric vault requirements for 277/480V single 3-phase transformer installation.

CUST. BOARD	480V TRANSF. SIZE	FRONT TO BACK*	WALL TO WALL	ALONG W/ TRANSF. SWITCH INSTALLED ON SIDE WALL		ALONG W/ TRANSF. SWITCH INSTALLED ON END WALL		FLOOR TO CEILING	CEILING EQUIPMENT	TRANSF.	SUMP
SIZE	(KVA)	L LENGTH	W WIDTH	L LENGTH	W WIDTH	L LENGTH	W WIDTH	HEIGHT	OPENING	WEIGHT	CAP.
200	150	13' - 6"	9' - 6"	NA	NA	NA	NA	8' - 0"	4' - 6" X 6' - 6"	3,900	240
400	300	15' - 0"	10' - 6"	NA	NA	NA	NA	8' - 6"	6' - 0" X 7' - 6"	5,000	255
600	500	16' - 6"	12' - 6"	21' - 6"	15' - 0"	19' - 6"	20' - 0"	9' - 0"	6' - 6" X 7' - 6"	6,600	290
800	500	16' - 6"	12' - 6"	21' - 6"	15' - 0"	19' - 6"	20' - 0"	9' - 0"	6' - 6" X 7' - 6"	6,600	290
1000	750	17' - 0"	12' - 6"	22' - 6"	15' - 0"	20' - 0"	20' - 0"	9' - 0"	7' - 0" X 7' - 6"	7,550	425
1200	1000	18' - 0"	13' - 6"	23' - 6"	16' - 6"	21' - 6"	20' - 0"	10' - 0"	8' - 0" X 7' - 6"	8,200	435
1600	1000	18' - 0"	13' - 6"	23' - 6"	16' - 6"	21' - 6"	20' - 0"	10' - 0"	8' - 0" X 7' - 6"	8,200	435
2000	1500	20' - 0"	16' - 0"	25' - 6"	19' - 0"	23' - 0"	20' - 0"	11' - 0"	10' - 0" X 9' - 0"	10,150	515
2500	2000	20' - 0"	16' - 6"	25' - 6"	19' - 6"	23' - 0"	20' - 0"	12' - 0"	10' - 0" X 10' - 0"	17,300	570
3000	2000	20' - 0"	16' - 6"	25' - 6"	19' - 6"	23' - 0"	20' - 0"	12' - 0"	10' - 0" X 10' - 0"	17,300	570
4000	2500 3000**	20' - 0"	16' - 6"	25' - 6"	19' - 6"	23' - 0"	20' - 0"	12' - 0"	10' - 0" X 10' - 0"	17,300	580

24.6.4. Below grade multiple transformer installation 277/480V side by side minimum vault dimensions for multi-services.

LENGTH	13'-6"	15'-0"	16'-6"	16'-6"	11'-0"	12'-0"	18'-0"	20'-0"	20'-0"	20'-0"	20'-0"
-	200i	400i	600i	800i	1000i	1200i	1600i	2000i	2500i	3000i	4000i
WIDTH "A"	9'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	16'-0"	16'-6"	16'-6"	16'-6"	16'-6"
WIDTH "B"	7'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"	12'-6"	12'-6"	12'-6"

WIDTH "A" = Minimum vault requirements for one service panel according to main size
 WIDTH "B" = Additional vault requirements for each added service main

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SDG&E ELECTRIC VAULT REQUIREMENTS AND SPECIFICATIONS

FMO
DM5745.2

24.6.5. On grade minimum electric vault requirements for 120/208V single 3-phase transformer installation.

CUST. BOARD	208V TRANSF. SIZE	FRONT TO BACK*	WALL TO WALL	ALONG W/ TRANSF. SWITCH INSTALLED ON SIDE WALL		FLOOR TO CEILING	ON GRADE EQUIPMENT OPENING		TRANSF.	SUMP	CLEAR & LEVEL WORKING SPACE IN FRONT OF EQUIPMENT OPENING	
SIZE	(KVA)	L LENGTH	W WIDTH	L LENGTH	W WIDTH	HEIGHT	WIDE	WIDE	WEIGHT	CAP	WIDE	WIDE
200	75	14' - 6"	9' - 6"	14' - 6"	12' - 6"	8' - 0"	7' - 6"	6' - 6"	3,500	240	6' - 0"	7' - 6"
400	150	14' - 6"	9' - 6"	14' - 6"	12' - 6"	8' - 0"	7' - 6"	7' - 6"	3,900	240	6' - 0"	7' - 6"
600	225	16' - 0"	9' - 6"	16' - 0"	12' - 6"	8' - 0"	7' - 6"	7' - 6"	4,200	240	6' - 0"	7' - 6"
800	300	17' - 0"	10' - 6"	17' - 0"	13' - 6"	8' - 0"	8' - 6"	8' - 6"	5,000	255	7' - 0"	8' - 6"
1000	300	17' - 0"	10' - 6"	17' - 0"	13' - 6"	8' - 0"	8' - 6"	8' - 6"	5,000	255	7' - 0"	8' - 6"
1200	500	19' - 6"	12' - 6"	19' - 6"	12' - 6"	9' - 0"	8' - 6"	8' - 6"	6,600	290	7' - 0"	8' - 6"
1600	500	19' - 6"	12' - 6"	19' - 6"	12' - 6"	9' - 0"	8' - 6"	8' - 6"	6,600	290	7' - 0"	8' - 6"
2000	750	20' - 0"	12' - 6"	20' - 0"	15' - 6"	9' - 0"	8' - 6"	8' - 6"	7,550	425	8' - 0"	8' - 6"
2500	1000	21' - 0"	13' - 6"	21' - 0"	16' - 6"	10' - 0"	8' - 6"	8' - 6"	8,200	435	8' - 0"	8' - 6"
3000	1000	21' - 0"	13' - 6"	21' - 0"	16' - 6"	10' - 0"	8' - 6"	8' - 6"	8,200	435	8' - 0"	8' - 6"
4000	100cr... 1500..	23' - 0"	16' - 0"	23' - 0"	19' - 0"	11' - 0"	10' - 0"	10' - 0"	10,150	515	10' - 0"	10' - 0"

24.6.6. On grade multiple transformer installation 120/208V side by side minimum vault dimensions for multi-services.

LENGTH	14'-6"	14'-6"	16'-0"	11'-0"	11'-0"	19'-6"	19'-6"	20'-0"	21'-0"	21'-0"	23'-0"
-	200i	400i	600i	800i	1000i	1200i	1600i	2000i	2500i	3000i	4000i
WIDTH "A"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	13'-6"	16'-6"
WIDTH "B"	7'-6"	7'-6"	7'-6"	8'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"

WIDTH "A" = Minimum vault requirements for one service panel according to main size

WIDTH "B" = Additional vault requirements for each added service main

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C	EDITORIAL CHANGES	YZZ	EJA	MRF	MRF	04/13/2026	F						
B	EDITORIAL CHANGES	YZZ	JES	FRC	JJP	10/31/2025	E						
A	ORIGINAL ISSUE	-	-	-	-	11/20/2018	D	5745 TABLES MOVED TO FMO	YZZ	FRC	FRC	FRC	07/22/2026

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SDG&E ELECTRIC VAULT REQUIREMENTS AND SPECIFICATIONS

FMO
DM5745.3

24.6.7. On grade minimum electric vault requirements for 277/480V single 3-phase transformer installation.

CUST. BOARD	480V TRANSF. SIZE	FRONT TO BACK*	WALL TO WALL	ALONG W/ TRANSF. SWITCH INSTALLED ON SIDE WALL		FLOOR TO CEILING	ON GRADE EQUIPMENT OPENING		TRANSF.	SUMP	CLEAR & LEVEL WORKING SPACE IN FRONT OF EQUIPMENT OPENING	
SIZE	(KVA)	L LENGTH	W WIDTH	L LENGTH	W WIDTH	HEIGHT	WIDE	WIDE	WEIGHT	CAP	WIDE	WIDE
200	150	14' - 6"	9' - 6"	14' - 6"	12' - 6"	8' - 0"	7' - 6"	7' - 6"	3,900	240	6' - 0"	7' - 7"
400	300	11' - 0"	10' - 6"	17' - 0"	13' - 6"	8' - 6"	8' - 0"	8' - 6"	5,000	255	7' - 0"	8' - 6"
600	500	19' - 6"	12' - 6"	19' - 6"	15' - 6"	9' - 0"	8' - 6"	8' - 6"	6,600	290	7' - 0"	8' - 6"
800	500	19' - 6"	12' - 6"	19' - 6"	15' - 6"	9' - 0"	8' - 6"	8' - 6"	6,600	290	7' - 0"	8' - 6"
1000	750	12' - 0"	12' - 6"	20' - 0"	15' - 6"	9' - 0"	8' - 6"	8' - 6"	7,500	425	8' - 0"	8' - 6"
1200	1000	21' - 0"	13' - 6"	21' - 0"	16' - 6"	10' - 0"	8' - 6"	8' - 6"	8,200	435	8' - 0"	8' - 6"
1600	1000	21' - 0"	13' - 6"	21' - 0"	16' - 6"	10' - 0"	8' - 6"	8' - 6"	8,200	435	8' - 0"	8' - 6"
2000	1500	23' - 0"	16' - 0"	23' - 0"	19' - 0"	11' - 0"	10' - 0"	10' - 0"	10,150	515	10' - 0"	10' - 0"
2500	2000	23' - 0"	16' - 6"	23' - 0"	19' - 6"	12' - 0"	10' - 0"	10' - 0"	17,300	570	10' - 0"	10' - 0"
3000	2000	23' - 0"	16' - 6"	23' - 0"	19' - 6"	12' - 0"	10' - 6"	10' - 0"	17,300	570	10' - 0"	10' - 0"
4000	2500 3000*	23' - 0"	16' - 6"	23' - 0"	19' - 6"	12' - 0"	10' - 6"	10' - 0"	17,300	580	10' - 0"	10' - 0"

24.6.8. On grade multiple transformer installation 277/480V side by side minimum vault dimensions for multi-services.

LENGTH	14'-6"	11'-0"	19'-6"	19'-6"	20'-0"	21'-0"	21'-0"	23'-0"	23'-0"	23'-0"	23'-0"
-	200i	400i	600i	800i	1000i	1200i	1600i	2000i	2500i	3000i	4000i
WIDTH "A"	9'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	16'-0"	16'-6"	16'-6"	16'-6"	16'-6"
WIDTH "B"	7'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"	12'-6"	12'-6"	12'-6"

WIDTH "A" = Minimum vault requirements for one service panel according to main size
 WIDTH "B" = Additional vault requirements for each added service main

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A	ORIGINAL ISSUE	-	-	-	-	11/20/2018	D	5745 TABLES MOVED TO FMO	YZZ	FRC	FRC	FRC	07/22/2026

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	SDG&E ELECTRIC VAULT REQUIREMENTS AND SPECIFICATIONS								

5800
CAPACITORS

5800
CAPACITORS

5800 - No FMO standards for this section.

5900

WIRE & SUPPORTS

5900

WIRE & SUPPORTS

SUBJECT

5931

DETERMINING GUY REQUIREMENTS WITH THE GUY COMPUTER

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WIRES AND SUPPORT

FMO
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DM5931 FIELD MAINTENANCE ONLY

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REVISION HISTORY:

08/18/2026: MOVED TO FMO. DESIGN IS DONE IN PLS-CADD AND O-CALC. THE CALCULATOR IS NO LONGER USED.

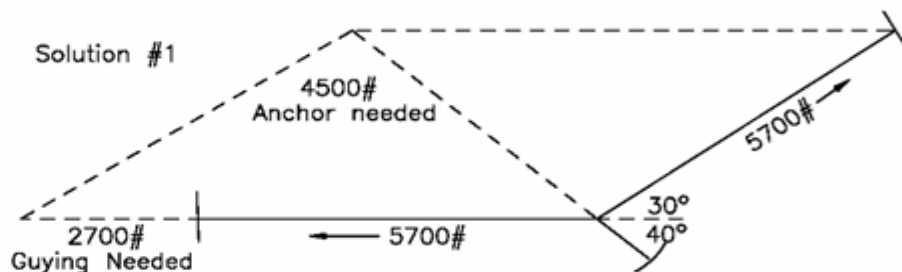
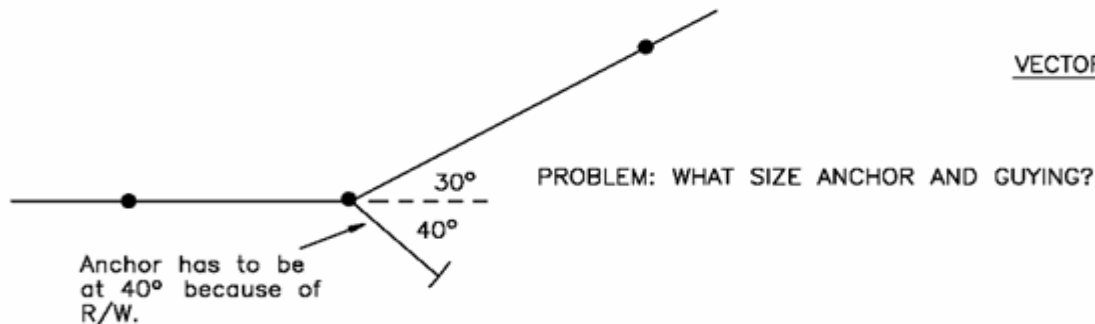
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	DETERMINING GUY REQUIREMENTS WITH THE GUY COMPUTER								

FMO
DM5931.1

VECTORIZING



When using rotating arm scale, all readings are perpendicular to the upper scale edge.

Example No. 2

To Determine

1. Resultant Tension or Pull when anchor is to be installed on the bisection of angle in the line.
2. Angle which guy makes with pole.
3. Tension on guy wire.
4. Size of guy wire, using a factor safety of 2.

Given

Length of pole..... 45 ft.
Horizontal Distance anchor hole to pole..... 37 ft.
Length of anchor rod..... 10 ft.
Number of conductors at top circuit position . 3-#1/0 and 1 - #2 B. Str. H.D.
Angle of departure of line..... 24°

Solution

1. Use 10 ft anchor chart. Under the title "Total Horizontal Conductor Pull" at top of chart in Hard Drawn Bare Stranded section on the line containing 4 wire combinations, find 3 - #1/0 and 1- #2. Follow this dashed line to where it intersects the arc line. Rotate scale arm to where upper edge coincides with this intersection. Find 24° on 2nd line of rotating scale. Mark this point at upper scale edge. Swing scale to horizontal positions. Project a line from point vertically downward to scale, read 2900#, which is the total horizontal pull.

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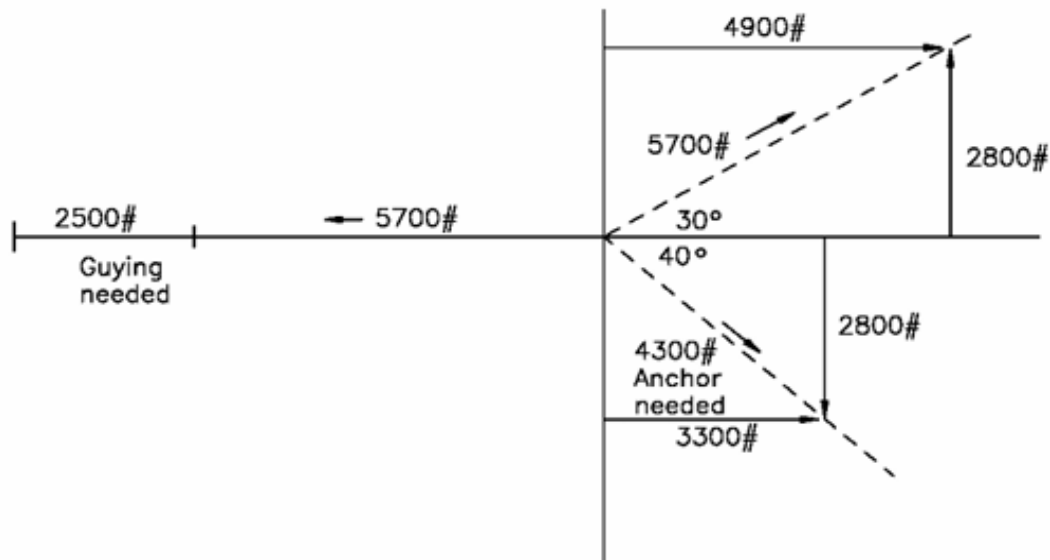
DETERMINING GUY REQUIREMENTS WITH THE GUY COMPUTER

FMO
DM5931.2

2. Find guy angle by method described in previous problem, answer – 39°.
3. Set scale arm on 39° . Read tension on scale where previously projected 2900# line intersects 39° line, answer – 4600#
4. The 4600# guy tension falls within the band marked for 3/8" A.T. & T.

If the guy angle has not previously been determined and it is desired to make the most of shortened "lead" distance and maximum use of any indicated size of guy wire, this can be accomplished by the following operation. Rotate the scale arm to where 5750# (maximum safe tension for 3/8" A.T.&T.) on scale arm coincides with previously projected 2900# line. The scale arm will reset on the 31° angle. Find intersection of pole height curve line for 45' pole and follow vertically downward to Horizontal Distance scale, read 27'. Similarly follow through for 7/16" A.T. & T (9000# max.) Answers—19° and 16'. Inspection will show that 5/16" A. T. & T. is applicable in this case only to an angle such as those produced by head guys.

Solution #2



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DETERMINING GUY REQUIREMENTS WITH THE GUY COMPUTER

FMO
DM5931.3

6000
SUBSTATION
LOAD FORECASTING

6000
SUBSTATION
LOAD FORECASTING

6000 - No FMO standards for this section.

6100
SECTIONALIZING
& PROTECTION

6100
SECTIONALIZING
& PROTECTION

SUBJECT

OVERHEAD SERVICE RECLOSER APPLICATION CRITERIA

UNDERGROUND SERVICE RESTORER

RELAY AND FUSE COORDINATION TABLES

SERVICE RESTORER/FUSE COORDINATION TABLE

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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY					
	TABLE OF CONTENTS SECTIONALIZING AND PROTECTION					

SCOPE

This design standard provides application criteria for service restorers used to protect overhead feeders.

PURPOSE

Service restorers are placed on 12kV overhead circuits to reduce the number of customers effected by service interruptions. Service restorers act as on-line OCB's, clearing transient faults and locking open permanent faults. They reduce substation OCB operations. Only customers downstream of the device are affected by it.

DEFINITIONS

Service Restorer – the term used to identify an electronically controlled distribution line recloser.

Electronically Controlled Distribution Line Recloser – provides automatic sectionalizing of feeder circuits. It has the ability to re-energize the feeder up to three times, prior to remaining permanently open, in an attempt to restore service.

Major Critical Customer – the term used for those customers exceeding 1000KVA connected load who are engaged in life support activities, protection of the public, or where large groups of people may be present. Facilities such as hospitals, military installations, major law enforcement and fire protection installations, major shopping centers, high rise buildings, and customers with critical manufacturing processes shall be considered major critical customers.

CRITERIA

- A. A Service Restorer should be installed on any 12kV circuit which serves at least 1000 customers, provided it meets one of the following conditions:
 1. The total unfused feeder circuit length is at least 14 miles.
 2. The circuit has experienced at least 2 environmentally caused feeder interruptions over the last 3 years (such as trees, weather, foreign objects) and the total unfused feeder circuit length is at least 6 miles.
- B. A Service Restorer may be installed on the source side of a feeder line segment which has experienced at least 2 environmental interruptions over the last three years, provided it protects a Major Critical Customer. This may be done on circuits which do not meet the 1000 customer requirement.

APPLICATION

- A. Service Restorers Installed according to criteria A shall be placed at the following locations:
 1. The Service Restorer should be located so that at least half the circuit load is protected. This means that less than half the load shall be on the load side of the Service Restorer.
 2. The Service Restorer should be located on the load side of the feeder line segments which are subject to environmental interruptions.

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C	6112 MOVED TO FMO	YZZ	MOV	FRC	FRC	08/28/2026	F						
B	REVISION	-	-	-	JCE	03/01/2002	E						
A	ORIGINAL ISSUE	-	-	-	CAK	01/01/1987	D						

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	OVERHEAD SERVICE RESTORER APPLICATION CRITERIA			

**FMO
DM6112.1**

- B. Service Restorers shall be accessible to a troubleshooter in all weather. Vehicle access shall be provided within 100 feet of the Service Restorer.
- C. A Service Restorer is controlled by electronic relays which sense phase and ground fault currents. Distribution Planning is responsible for establishing the control settings based upon load and fault current provided by Protection Engineering. Therefore, Distribution Planning must be contacted prior to preparing a workorder to install a Service Restorer.

OPERATION

- A. If the fault current is such that the recloser operates in the range of the time time curve settings.
1. The Service Restorer will open once a fault exceeding the phase or ground trip setting is detected.
 2. The Service Restorer will close 5 seconds later in an attempt to restore service.
 3. The Service Restorer will open again if the fault is still present. Otherwise, it will remain closed and service will have been restored.
 4. The Service Restorer will close 10 seconds later in a second attempt to restore service.
 5. The Service Restorer will open again, and remain permanently open, if the fault is still present. A troubleman will be required to manually reset the Service Restorer before it can be closed again.
- B. If the fault current is high enough to activate the instantaneous curve the following typical control settings in use at SDG&E curve the following Service Restorer operations:
1. The Service Restorer will open on the instantaneous trip.
 2. The Service Restorer will close 5 seconds later in an attempt to restorer service.
 3. The Service Restorer will open again, and remain open, if the fault is still present.

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OVERHEAD SERVICE RESTORER APPLICATION CRITERIA

**FMO
DM6112.2**

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B							E						
A	6114 MOVED TO FMO	JIK	MAK	FRC	KRG	09/16/2024	D						

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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY								
	UNDERGROUND SERVICE RESTORER								

SCOPE

This document provides criteria for the selection and application of 12KV feeder sectionalizing devices on selected high-risk circuits.

PURPOSE

Application of automatic sectionalizing devices for underground circuits (pad-mounted service restorer and PME3 with SCADA) can be beneficial in reducing the number of customers affected by service interruptions. These devices are also helpful in reducing the projected SAIDI by minimizing the impact of a failure of the unfused high molecular polyethylene (HMWPE or PECH in GFMS or unjacketed cross-linked polyethylene (XLPE) cable.

CRITERIA

- A. Circuits chosen for study should meet one or more of the following:
 - 1. A high amount of unfused type HMWPE or XLPE cable as defined by
 - a. Total cable length exceeding one mile or
 - b. Exceeding 20 percent of the total underground cable length
 - 2. Underground outage history exceeding three feeder outages over the last three years regardless of cause.
- B. In addition to the above, the application must be prioritized based on the cost-to-benefit (C/B) ratio analysis in Design Manual section 6145. The projected value (the inverse of the C/B ratio) must be greater than one to justify the additional sectionalizing devices. Alternate methods of project methods of project justification may be allowed by Electric Distribution Planning.

APPLICATION

The circuit under consideration must be examined to ensure that it will meet the switching provisions of Design Manual section 6111 after modification. Service restorers are the preferred device because of the automatic operation and the fact that they can immediately reduce the number of customers affected by an outage. If a service restorer is already in use on a circuit, the PME3 with SCADA should be used where substation SCADA is available or will be available within two years. In cases where the frequency is not as critical, the PME3 with SCADA may be the most economical choice.

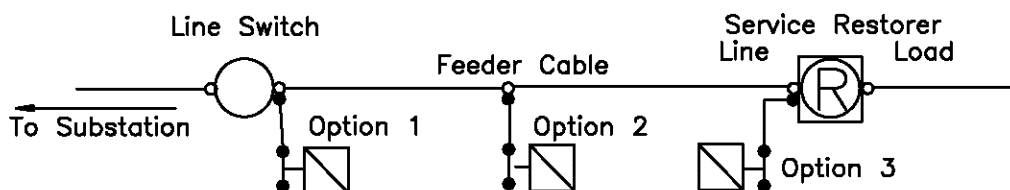
- 1. 600A Padmounted Service Restorer
 - a. Consideration must be made regarding the location and length of the unfused cable segments when locating the service restorer. As a general guide, locate the service to maximize the amount of load on the line side of the device and to maximize the circuit length on load side. The service restorer should be located to protect at least one half of the circuit load. If this is not practical, locate to maximize the isolation of the unfused cable sections.
 - b. A line switch is required immediately ahead of the service restorer for maintenance. This may be an overhead gang operated or hookstick switch, a padmount switch, a handhole switch (On-Off), or a manhole switch (group/On-Off). Manhole switches are acceptable for this application but they are not preferred.

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APPLICATION (continued)

- c. No load should be connected between the service restorer and the line switch immediately ahead. An exception to this rule would be the placement of a single phase transformer that would only provide secondary service for the actuator device within the service restorer. This single phase transformer may tap the feeder at either the switch, the service restorer or in between. Following is an illustrative one-line diagram for the three optional hookups.



Special Note: DM 6121.3.d.1 requires that a fuse request be submitted and approved prior to installation of un-fused transformer stations.

- d. If the service restorer is located so as to protect a purely underground section it shall be set for one test reclosing 5 seconds after the fault, then lockout. Distribution Planning will determine the number of test reclosings for circuits with overhead spans on the load side of the service restorer.
- e. Distribution Planning must be contacted to obtain settings for all protective devices on the circuit.

2. PME3 with SCADA or SCADA Overhead Switch

The PME3 with SCADA should be applied in cases where: 1) A feeder has an existing service restorer and protection (fuse) coordination is not possible. 2) The less expensive SCADA switch will provide adequate protection for the circuit being studied.

- a. If existing subsurface or padmount switchgear is strategically placed for service restoration contact Electric Distribution Standards about SCADA actuator retro-fit. This option can be more economical than other options.
- b. Install SCADA type switches at the midpoint, one-quarter and three-quarter points on the feeder in that order of preference. These may be the new PME3 SCADA switch, SCADA overhead switch, or an existing underground switch retro-fitted with SCADA.
- c. SCADA operated devices may be installed on feeders from current non-SCADA substations where SCADA is not planned within two years. Substations where SCADA is not planned within two years will limit options to automatic protection devices.
- d. Consideration should be given to converting strong tie switches to SCADA.

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6114.2

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UNDERGROUND SERVICE RESTORER APPLICATION CRITERIA

REVISION

DATE 1-1-94

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RELAY AND FUSE COORDINATION TABLES

FMO
DM6134.1

MINIMUM LINE-TO-GROUND FAULT CURRENT REQUIRED FOR COORDINATION																									
Relay Type	KEARNY QA					S&C SM-4					FUSE					TYPE/SIZE			EOD/SD EJO-1			KB		RTE	FE
	75	100	125	150	200	65	80	100	125	150	200	80	100	150	200	80	150								
CO-8	*	1950	3300	4800	8400	*	2100	3300	5100	6600	8400	*	1050	2700	3900	750	2850	3900	*	2070	2460	3900	*		
	*	*	1350	2730	5400	*	*	1200	2700	3900	4800	*	900	2040	2910	*	*	1770	2100	*	1770	2100	*		
	*	*	*	1800	3900	*	*	840	1590	2550	3450	*	1830	2670	*	*	*	1350	1650	*	1350	1650	*		
	*	*	*	1500	3300	*	*	*	1260	1860	2820	*	*	1770	2490	*	*	*	1320	1290	*	1320	1290	*	
	*	*	*	1260	2700	*	*	*	1110	1560	2460	*	*	1710	2400	*	*	*	1320	1290	*	1320	1290	*	
IAC53	1350	2640	3750	5250	9000	660	2700	3900	5700	7200	8700	675	1200	3000	4200	900	3300	4200	*	2160	3600	4200	700		
	*	*	2250	3750	6750	*	750	2100	3300	4800	6300	*	960	2250	3300	*	*	2160	3600	*	2160	3600	*		
	*	*	1110	2700	5400	*	*	1140	2700	3900	5100	*	900	2040	2850	*	*	1800	2400	*	1800	2400	*		
	*	*	900	2100	4500	*	*	900	1920	3300	4200	*	840	1890	2700	*	*	1560	2100	*	1560	2100	*		
	*	*	*	1500	3900	*	*	840	1350	2350	3450	*	*	1800	2550	*	*	1350	1800	*	1350	1800	*		
CO 1	*	*	2100	3750	5600	*	810	2100	3600	4800	5850	*	*	2250	3300	*	2160	3300	*	1620	2100	3300	*		
	*	*	840	2100	4500	*	*	840	1980	3000	4500	*	*	1950	2700	*	*	1620	2100	*	1620	2100	*		
	*	*	*	1350	3750	*	*	*	1290	2100	3300	*	*	1800	2550	*	*	1350	1650	*	1350	1650	*		
	*	*	*	1230	3000	*	*	*	1140	1680	2700	*	*	1740	2400	*	*	1290	1500	*	1290	1500	*		
	*	*	*	1200	2550	*	*	*	1050	1500	2340	*	*	1650	2370	*	*	1260	1350	*	1260	1350	*		
CO-Al	*	2400	5400	7200	11700	*	2100	3300	4800	6300	7500	720	1200	3000	3900	900	3300	4200	*	2400	3300	4200	700		
	*	*	2100	3000	5100	*	*	1380	2700	3900	4800	*	990	2250	3030	*	*	3300	4200	*	2400	3300	*		
	*	*	1050	2100	4500	*	*	*	1650	2700	3600	*	900	2010	2730	*	*	1950	2230	*	1950	2230	*		
	*	*	*	1680	3600	*	*	*	1320	2040	2850	*	*	1860	2640	*	*	1740	1950	*	1740	1950	*		
	*	*	*	1350	2800	*	*	*	1140	1650	2400	*	*	1800	2460	*	*	1500	1750	*	1500	1750	*		
IAC51	1500	2100	3000	4050	6600	1560	2100	3000	3900	4800	6000	900	1350	2750	3600	1250	3000	3600	*	2400	3600	3600	900		
	1050	1500	2100	2700	4650	960	1380	1800	2490	3600	4050	800	1125	2250	3000	1000	2400	2700	*	2400	3600	3600	750		
	650	1125	1650	2250	4050	660	990	1350	2030	2700	3150	750	1050	2000	2700	800	2100	2400	*	2400	3600	3600	600		
	*	975	1350	1900	3600	*	840	1110	1710	2100	2700	680	1000	1900	2600	750	1800	2100	*	2400	3600	3600	600		
	*	840	1200	1750	3000	*	750	1020	1500	2010	2550	675	975	1800	2500	675	1650	1900	*	2400	3600	3600	900		
IT >	1250	1500	2000	2500	3750	1300	1600	2000	2500	3100	3700	650	800	1500	1800	800	1700	2000					550		

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A	REVISION	-	-	-	JCE	01/01/2000	D						

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	RELAY AND FUSE COORDINATION TABLES								

MINIMUM LINE-TO-GROUND FAULT CURRENT REQUIRED FOR COORDINATION

Relay Type	75	100	125	150	200	S&C SM-4	65	80	100	125	150	200	TYPE/SIZE	80	100	150	200	EOD/SD EJO-1	KB	80	150	RTE	150	FE	30
CO-B	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	1800	2550	3700	6000	1500	2100	3300	4200	5400	1200	2400	3150	2700	3200	2400	1800	1350	3300	2400	1800	1350	3300	2400	1800	1350
IAC53	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	1350	3300	4800	8400	2700	6000	1200	2700	5100	1380	2850	2040	1920	1680	1980	2940	1560	1290	1260	2250	1500	1275	2250	1500	1275
CO-1	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	2460	6000	1200	4200	2700	2100	3300	5400	6600	2250	3600	2200	1950	1770	2310	3300	2430	1500	1330	3300	2430	1500	1330	3300	2430
CO-A1	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	2100	3900	7500	1350	4800	3300	5400	6600	2250	3600	2200	1950	1770	2310	3300	2430	1500	1330	3300	2430	1500	1330	3300	2430	1500
IAC51	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
	1800	2550	3700	6000	1500	2100	3300	4200	5400	1200	2400	3150	2700	3200	2400	1800	1350	3300	2400	1800	1350	3300	2400	1800	1350
IT >	1250	1500	2000	2500	3750	1300	1600	2000	2500	3100	3700	650	800	1500	1800	800	1700	2000	550						

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RELAY AND FUSE COORDINATION TABLES

FMO
DM6134.2

MINIMUM LINE-TO-GROUND FAULT CURRENT REQUIRED FOR COORDINATION																													
Relay Type	KEARNY QA					S&C SM-4					FUSE					TYPE/SIZE					EOD/SD EJO-1					KB		RTE	FE
	75	100	125	150	200	65	80	100	125	150	200	80	100	150	200	80	150	200	250	300	350	400	450	500					
CO-8	*	*	*	2700	7200	*	*	*	1950	4050	6000	*	*	1950	2940	*	1425	2250	*	*	*	*	*	*	*				
	*	*	*	3900	3900	*	*	*	1680	1300	2400	*	*	1680	2490	*	*	*	*	*	*	*	*	*	*				
	*	*	*	2200	2200	*	*	*	1530	*	1920	*	*	1530	2340	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1800	1800	*	*	*	*	*	1740	*	*	*	2190	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1650	1650	*	*	*	*	*	1650	*	*	*	2100	*	*	*	*	*	*	*	*	*	*				
IAC53	*	*	*	3900	8100	*	*	*	3600	4800	6900	*	*	2190	3000	*	2040	3450	*	*	*	*	*	*	*				
	*	*	*	5100	5100	*	*	*	*	1350	3600	*	*	1800	2700	*	1290	1650	*	*	*	*	*	*	*				
	*	*	*	2640	2640	*	*	*	*	*	2220	*	*	1650	2430	*	*	*	*	*	*	*	*	*	*				
	*	*	*	2040	2040	*	*	*	*	*	1920	*	*	1560	2400	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1800	1800	*	*	*	*	*	1740	*	*	*	2280	*	*	*	*	*	*	*	*	*	*				
CO 1	*	*	*	1170	5400	*	*	*	*	1380	4200	*	*	1800	2670	*	1290	1650	*	*	*	*	*	*	*				
	*	*	*	2490	2490	*	*	*	*	*	1920	*	*	1560	2370	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1890	1890	*	*	*	*	*	1680	*	*	*	2250	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1740	1740	*	*	*	*	*	1650	*	*	*	2100	*	*	*	*	*	*	*	*	*	*				
	*	*	*	*	*	*	*	*	*	*	1630	*	*	*	2100	*	*	*	*	*	*	*	*	*	*				
CO-A1	*	*	*	2850	6900	*	*	*	*	4200	5900	*	*	1950	3000	*	1700	2100	*	*	*	*	*	*	*				
	*	*	*	4200	4200	*	*	*	*	*	2700	*	*	1700	2550	*	*	*	*	*	*	*	*	*	*				
	*	*	*	2050	2050	*	*	*	*	*	1800	*	*	1500	2350	*	*	*	*	*	*	*	*	*	*				
	*	*	*	1700	1700	*	*	*	*	*	*	*	*	*	2200	*	*	*	*	*	*	*	*	*	*				
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	2100	*	*	*	*	*	*	*	*	*	*				
IAC51	*	*	*	3600	6000	*	*	*	3000	3700	5150	*	*	2250	3000	*	2550	3000	*	*	*	*	*	*	*				
	*	*	*	3000	4500	*	*	*	1880	2700	3400	*	*	2000	2700	*	1950	2250	*	*	*	*	*	*	*				
	*	*	*	1650	3600	*	*	*	1320	1920	2700	*	*	1850	2500	*	1650	1900	*	*	*	*	*	*	*				
	*	*	*	1400	2700	*	*	*	*	1600	2300	*	*	1800	2400	*	1500	1750	*	*	*	*	*	*	*				
	*	*	*	1250	2400	*	*	*	*	1470	2100	*	*	1700	2250	*	1350	1500	*	*	*	*	*	*	*				
IT >	1250	1500	2000	2500	3750	1300	1600	2000	2500	3100	3700	650	800	1500	1800	800	1700	2000	2000	2000	2000	2000	2000	2000	550				
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B	6134 MOVED TO FMO	YZZ	DJB	FRC	FRC	04/20/2026	E						
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RELAY AND FUSE COORDINATION TABLES

FMO
DM6134.3

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SERVICE RESTORER/FUSE COORDINATION TABLE

FMO
DM6136.1

SCOPE: This standard shows the minimum line to ground fault current required for safe coordination between service restorers and fuses.

Service Restorer Ground Slow Setting Curve		Fuse Type/Size															
		QA															
		15	20	25	30	40	50	60	75	100	125	150	200	30	80	150	
14	18	125	300	400	525	675	875	1050	1500	1975	2725	3300	4800	750	1250	2700	
14	14	250	425	450	575	750	925	1200	1550	2100	2700	3250	5100	825	1350	2700	
14	8	450	600	750	900	1150	1550	1750	2400	3000	3900	4800	7500	850	1800	3600	
14	3	125	225	275	375	525	625	825	1125	1500	1800	2400	3750	700	1050	2100	
14	2	175	300	400	525	650	825	1050	1350	1800	2400	3000	4500	725	1200	2475	
14	K	300	1500	1800	2250	2700	3200	4400	6000	7600	10000	12000	18000	1050	2550	5400	
70	18	*	*	*	*	225	325	450	1050	1725	2325	3000	4650	600	1050	2550	
70	14	*	*	*	225	450	750	975	1450	1950	2475	3150	5100	725	1200	2650	
70	8	*	*	*	600	975	1275	1550	2400	3000	3900	4800	7500	650	1500	3000	
70	3	*	*	*	*	250	375	450	750	1175	1575	2175	3750	550	900	1950	
70	2	*	*	*	*	275	400	550	1075	1575	2175	2925	4500	600	1050	2400	
70	K	*	*	*	*	*	*	*	1800	4500	10000	12000	18000	550	1050	4500	
100	18	*	*	*	*	*	*	325	525	1050	2000	2700	4500	525	750	2325	
100	14	*	*	*	*	*	425	750	1350	1825	2425	3100	5100	700	1150	2625	
100	8	*	*	*	*	600	1050	1425	2250	3000	3900	4800	7500	750	1650	3600	
100	3	*	*	*	*	*	*	375	600	900	1350	1950	3600	525	750	1850	
100	2	*	*	*	*	*	300	425	750	1350	1900	2700	4500	575	875	2250	
100	K	*	*	*	*	*	*	*	*	600	5200	9000	18000	*	650	3300	
140	18	*	*	*	*	*	275	375	600	1350	2100	2850	4500	450	650	2050	
140	14	*	*	*	*	*	*	425	1150	1725	2400	3000	5100	600	1050	2500	
140	8	*	*	*	*	*	450	1200	2100	3000	3900	4800	7500	700	1500	3600	
140	3	*	*	*	*	*	*	*	475	750	1050	1775	3300	*	450	1350	
140	2	*	*	*	*	*	*	*	550	900	1500	2400	4500	400	725	2100	
140	K	*	*	*	*	*	*	*	*	*	825	4200	19500	525	675	2250	
170	18	*	*	*	*	*	*	*	*	600	900	1800	4500	*	600	1650	
170	14	*	*	*	*	*	*	*	750	1500	2100	3000	4900	550	900	2400	
170	8	*	*	*	*	*	*	750	1350	2700	3750	4800	7500	675	1250	3300	
170	3	*	*	*	*	*	*	*	*	675	925	1500	2800	*	600	1500	
170	2	*	*	*	*	*	*	*	*	725	1075	2050	4450	*	675	1800	
170	K	*	*	*	*	*	*	*	*	*	*	1200	13500	*	*	1350	
200	18	*	*	*	*	*	*	*	*	*	775	1350	4200	*	*	1500	
200	14	*	*	*	*	*	*	*	*	1200	2050	2725	4600	*	750	2350	
200	8	*	*	*	*	*	*	*	1500	2550	3650	4500	7500	600	1350	3300	
200	3	*	*	*	*	*	*	*	*	600	850	1350	2700	*	600	1400	
200	2	*	*	*	*	*	*	*	*	600	900	1725	4200	*	650	1725	
200	K	*	*	*	*	*	*	*	*	*	*	1050	8500	*	*	1425	
240	18	*	*	*	*	*	*	*	*	*	*	1200	3400	*	*	1425	
240	14	*	*	*	*	*	*	*	*	750	1725	2700	4600	*	*	2200	
240	8	*	*	*	*	*	*	*	*	2100	3300	4500	7500	*	950	3200	
240	3	*	*	*	*	*	*	*	*	*	750	1250	2600	*	*	1350	
240	2	*	*	*	*	*	*	*	*	*	825	1350	3900	*	*	1500	
240	K	*	*	*	*	*	*	*	*	*	*	*	6000	*	*	*	
280	18	*	*	*	*	*	*	*	*	*	*	1050	2300	*	*	1275	
280	14	*	*	*	*	*	*	*	*	*	1200	2400	4500	*	*	2100	
280	8	*	*	*	*	*	*	*	*	1700	3000	4200	7500	*	*	3000	
280	3	*	*	*	*	*	*	*	*	*	*	1150	2100	*	*	1300	
280	2	*	*	*	*	*	*	*	*	*	*	1225	3000	*	*	1350	
280	K	*	*	*	*	*	*	*	*	*	*	*	1500	*	*	*	

NOTES:

* Will coordinate for all fault current values.

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SERVICE RESTORER/FUSE COORDINATION TABLE

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SYSTEM
ENGINEERING**

**6200
SYSTEM
ENGINEERING**

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SUBJECT

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6213	TRANSFORMER PRIMARY VOLTAGE SELECTION
6222	APPLICATION OF GROUNDING BANKS
6241	PRIMARY CONDUCTOR COST COMPARISON
6242	ECONOMIC EVALUATION OF ALTERNATIVES

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A	6222 MOVED TO FMO	JIK	FRC	FRC	KRG	09/16/2024	D	6241 MOVED TO FMO	YZZ	FRC	FRC	FRC	07/17/2026

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A	ORIGINAL ISSUE	YZZ	MOV	FRC	FRC	08/28/2026	D						

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SECTIONALIZING DEVICES ON DISTRIBUTION CIRCUITS

FMO
DM6205

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This standard describes the use of sectionalizing devices on distribution circuits.

This standard was established to explain the use of sectionalizing equipment on a typical distribution circuit. It is meant only to accompany the more specific application descriptions provided later in this section.

Certain guidelines must be followed when considering the selection and placement of sectionalizing devices. Refer to the table of contents, page 6101, for details on the application criteria of specific devices.

Fuses, service resters, and switches are used to sectionalize distribution circuits. These devices provide flexibility in configuration and help to limit service interruptions. Supervisory Control And Data Acquisition (SCADA) is used in substations for circuit breaker operations, voltage control, and load voltage control, and load monitoring. SCADA is also used to remotely control switches, in addition to collecting analog line data (Volts, Amps, Watts, etc.)

Legend	
	Banuelos Sub
	Fault Indicator
	Electronic Sectionalizer
	PME-10 with Scada
	Fuse Bypass
	Overhead Distribution
	Underground Distribution
	Overhead Fuse
	Hookstick Switch on Cable Pole
	Gang Operated Switch on Cable Pole
	OH Service Restorer with

Legend	
	Fault Indicator
	Electronic Sectionalizer
	PME-10 with Scada
	Fuse Bypass
	Overhead Distribution
	Underground Distribution
	Overhead Fuse
	Hookstick Switch on Cable Pole
	Gang Operated Switch on Cable Pole
	OH Service Restorer with By-Pass
	PME-9 Cabinet
	Gang Operated Switch
	Three Phase Transformer
	Primary Metering Station
	Capacitor
	Fuse Cabinet
	Fused Cable Pole
	Scada-Mate
	Padmount Service Restorer
	PME-11

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SECTIONALIZING DEVICES ON DISTRIBUTION CIRCUITS

FMO
DM6205.1

APPLICATION

A. Fuses

Fuses are used to isolate the distribution feeder from permanent faults on local distribution branches. Expulsion fuses are used to isolate the overhead feeder from faulted overhead or underground branches. Current limiting fuses isolate underground distribution from faulted equipment and protect unfaulted equipment from additional stress damage. SM-4 expulsion fuses can be used in PME-9 and PME-11 cabinets and can be applied in selected underground projects to accommodate higher loads, inrush, or primary service. Since fuses must be coordinated with other protective devices, the fusing specialist in Distribution Planning will specify all fuse sizes and types via the fusing request.

B. Service Restorers

A service restorer is composed of two primary parts; the recloser and the control. Service restorers are available in OH or UG (padmount) configurations. The service restorer can minimize the number of customers affected by an outage. This device can also be used to separate the rural and urban portions of a circuit. It can also isolate a bulk of circuit load from probable cable failure. Service restorers are usually installed such that one half of the circuit load, or more, is upstream of the device.

A service restorer serving overhead lines is usually set for one instantaneous trip operation, then two or three delayed operations prior to locking-out, in case of a permanent fault. These settings vary depending upon the application. Since underground faults are rarely temporary, a service restorer serving underground lines is normally set to lockout immediately upon sensing a fault. This mode of operation reduces stress on circuit components and minimizes power quality impact.

SCADA functionality is expected to be available on all new service restorers beginning calendar year 2000. Selected existing installations will also be eligible for control replacement providing SCADA functionality. Contact Distribution Standards for details.

Applications should be limited to cases where the feeder breaker is not yet on SCADA and the protected load is mostly commercial/industrial.

C. Switches

Manual padmounted switches and equipment are relatively easy and quick to operate, while subsurface equipment is the most difficult to access and operate quickly. Manual gang-operated overhead switches are equivalent in operability to pad mounted equipment.

SCADA equipment is by far the easiest and quickest to operate, as the Switching Center has direct, continuous control of all SCADA switches and equipment. See part E.

D. SCADA-Substation

SCADA is used for substation operations, data gathering, and distribution switching.

E. SCADA LINE/TIE SWITCH : THE OVERALL FAMILY OF SCADA LINE/TIE SWITCHES INCLUDES THE FOLLOWING:

- A) Overhead SCADA -MATE
- B) PME cabinet with SCADA (-3, -9, -10, -11 configurations)
- C) PME source-transfer cabinet with SCADA
- D) Vista switch with SCADA

All of the above devices except C can implement an autosectionalizing feature, providing automatic isolation of faulted feeder segments from the balance of the feeder within a minute. This feature does NOT require SCADA at the feeder breaker.

All the above devices provide continuous analog data, along with status and control of each switch. With the exception of the Vista switch supplied with fault interrupter modules, these devices do NOT have the ability to interrupt faults.

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APPLICATION

The application of the Vista switch with fault interrupting modules is limited to the downtown San Diego area, where a dry vault houses the switch and the interrupters serve loads in a radial manner only. Other Vista switch applications, with or without SCADA, are appropriate elsewhere if easement constraints preclude the ability to obtain easement for PME cabinet. This generally requires a deviation with evidence of easement with evidence of easement turn-down by property owners. The installed cost of the Vista switch is significantly higher than that of the PME cabinet, in all cases. Other constraints allowing Vista application include 1) retaining walls greater than 8 feet high for the PME cabinet, and 2) areas with zero structure set-backs.

F. ELECTRONIC SECTIONALIZER:

An overhead device, installed much like a fuse, that isolates faulted segments of the line automatically. Self contained, line powered electronics count the number of times fault current passes within a specified period. If the count meets or exceeds the value set by the manufacturer, the device will initiate an isolation of the line in between energized intervals. Upstream reclosing then closes and holds, restoring service to the balance of the circuit. Relatively economical, but limited ability to carry load (200 amps max.). Customers on the load side may be subject to single phase conditions when the sectionalizer operates. Requires Electric Trouble-shooter (ETS) response to reset once operated. Does not prevent line side customers from experiencing a momentary outage for load side faults; only prevents sustained outage.

G. FUSE-BYPASS:

Overhead installation including fuses in parallel with a hookstick switch or solid blade cutouts, providing the means to protect the feeder from load side faults while maintaining the functionality of tie switches. However, when the tie switch is used, ETS must also be dispatched to the fuse-bypass, some what complicating routine switching (parallels). Relatively economical, but obviously limited to less than 150-200 amps load. Will single phase load side customers.

H. CAM-LINK:

UG device providing the ability to quickly isolate UG feeder segments or equipment. Operable by a single ETS, the cam-link is a molded connector assembly including a removable, current carrying part that can be replaced with a non-current carrying counterpart. Can be operated only after both sides are tested deenergized. Can be installed within a 600 amp deadfront terminator to provide some basic feeder sectionalizing ability. Very economical and able to carry full line current. Installed on padmounted service restorers to provide a visible open that can be tagged as part of a line authorization. Also installed on PME-3 SCADA cabinets to allow quick isolation of voltage sensors prior to thumping or high-potting.

LEGACY SCADA SITES:

- I. Existing "Legacy" SCADA systems—installed on selected oil and SF6 subsurface and padmount switches between 1989 and 1996, to provide basic SCADA functionality (open/close status & control, plus fault indication). These sites do not have the ability to autosectionalize, nor is it feasible to add that feature. Analog line data not normally available. There are no plans to install additional sites using this kind of system. Examples include SCADA sites 98, 66, 43, etc. Contact Distribution Standards for more information.

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TRANSFORMER PRIMARY VOLTAGE SELECTION

FMO
DM6213

SCOPE

This standard provides the proper single-phase primary transformer voltage selection for boosted and unboosted areas on 12kV distribution circuits.

PURPOSE

This standard was developed to maintain 114 volts minimum (phase to neutral) at the customer's service entrance, based on the Distribution Circuit Profile (Design Standard 6211)

DEFINITIONS

Boosted Area – a physical location on a 12kV circuit served by a booster to provide 7,200 volts from a 12,000/6,930 volt source for proper operation of 7,200 volt transformers.

Boosted Rating – the kVA nameplate rating of 100 or 333 kVA–1Ø and 1875 or 3750 kVA–3Ø.

Booster Ultimate Loading – the maximum allowable peak loading of a booster is established as 100 percent of booster rating.

STANDARD

A. Boosted Area

Transformers rated 7,200 volts should be selected for boosted areas, provided the booster connected kVA will not exceed 90 percent of the booster rating with the kVA additions included.

- When exceeding 90 percent booster rating, Electric Distribution Planning approval is required for 7,200V transformer additions.

B. Unboosted Areas

1. Transformers rated 6,930 volts will always be selected for new installations in unboosted areas.
2. Transformers rated 6,930 volts will always be selected to replace existing 7,200V transformers in unboosted areas more than 1–1/2 miles from the distribution substation.
3. Transformers rated 6,930 volts will always be selected to replace existing 7,200V transformers in unboosted areas less than 1–1/2 miles from the distribution substation, provided the cost associated with converting live front (7,200V) to deadfront (6,930V) transformers is moderate and the interruption of service does not exceed 1 hour for commercial or 6 hours for residential customers. Where a high cost and/or extended outage time for the conversion is required, the replacement use of 7,200V transformers is acceptable.

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TRANSFORMER PRIMARY VOLTAGE SELECTION

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DM6213.1

Example:

Select the proper transformer primary voltage for the addition of 12–25 kVA single-phase transformers in a boosted area served by a 1875 kVA booster with 1400 kVA already connected.

1. Determine the booster loading requiring Electric Distribution Planning approval; 1875 kVA, booster rating (.9) = 1688 kVA
2. Determine total proposed connected kVA on the booster; 1400 kVA, existing + 300 kVA, proposed = 1700 kVA
3. Obtain Electric Distribution Planning approval for the proposed 7,200V transformer additions. Electric Distribution Planning should consider:
 - If the proposed additional transformers will result in the booster exceeding the booster ultimate loading due to actual demand.
 - If a 6,930 volt source should be brought into the area to serve the proposed additional transformers.

References:

1. Design Standard 6211, Distribution Circuit Voltage Profile
2. Service Planning Manual 353, Planned and Requested Outages

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TRANSFORMER PRIMARY VOLTAGE SELECTION

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APPLICATION OF GROUNDING BANKS

FMO
DM6222

SCOPE

This criteria shall be used for the application of grounding banks. Grounding banks provide a grounded neutral source that is required by load additions which are served by 6.9kV transformers.

DEFINITIONS

A grounding bank installation consists of three-phase transformers connected grounded wye-delta and is used to provide a ground source for the primary neutral wire. The primary voltage rating of the transformers used can be 12 or 6.9kV. The secondary voltage shall be rated 480 volts or higher (see O.H. Standards page 1195).

APPLICATION OF GROUNDING BANKS

A. Why Grounding Banks?

A grounding bank may be installed to serve single-phase load additions using 6.9kV transformers when there are two or fewer grounding banks on a circuit and:

1. Extension of an existing neutral wire, beyond the proper location for a grounding bank, is double the cost of a new grounding bank installation.
2. A neutral connected to an existing grounding bank is available, but additional single-phase load will exceed the recommended kVA limit on the existing grounding bank (see paragraph B.5).

B. Design Considerations

The following lists several design considerations related to the application of grounding banks.

1. The available short-circuit current sensed by a protective device is reduced approximately 100 amps for each grounding bank between the fault location and the substation. To prevent desensitization of the substation ground relays, the number of grounding banks on a circuit is limited to three installations.
2. A grounding bank should be installed at a central location to enable future loads to take advantage of this neutral source. Since there will normally be a maximum of three grounding banks per circuit, each grounding bank should be located to cover one third of the area served by the circuit.

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3. The recommended location for a grounding bank is on the unfused portion of a circuit, preferably on the feeder because the load on the grounding bank will be served by an energized neutral source except during times when the circuit is interrupted or the grounding bank has failed.
4. Neutrals established by grounding banks should only be used to serve transformers fed from the same circuit.
5. The following are approved grounding bank installations, allowable connected kVA unbalance between phases and maximum connected kVA loading.

Grounding Bank Installation	Allowable Connected kVA unbalance Between Phases	Maximum Connected kVA Loading (a)
3 – 50 kVA's	150 kVA	1500 kVA
3 – 75 kVA's	225 kVA	2250 kVA

- (a) The maximum connected kVA allowed was set at 10 times the unbalance which a grounding bank may tolerate because the load unbalance on the average circuit is 10 percent.
 - b. For more information on overhead grounding banks, refer to O.H. Standards Page 1195.
 6. Single-phase loads served from a grounding bank should be divided equally among the three phases to balance the total load as much as possible.
- If the amount of unbalance cannot be kept within the limits set above, one of the following must be done:
- a. Extend the neutral from the substation and remove the grounding bank. This alternative is recommended if there is significant load growth potential in the area.
 - b. Serve part of the load with 12kV single-phase transformers. Use enough 12kV transformers to reduce the amount of 6.9kV connected kVA below the recommended limit.
 - c. Extend the neutral from another grounding bank, either new or existing, and transfer some 6.9kV load to this neutral. These neutrals are not to be connected to each other.

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PRIMARY CONDUCTOR COST COMPARISON

FMO
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SCOPE

This standard uses graphic representation to illustrate the total owning cost (installation plus losses) of different conductor sizes operating at specific load levels. The information presented in this standard is supplemental to Design Standard 5923, "Preferred UG Cable Installation Criteria".

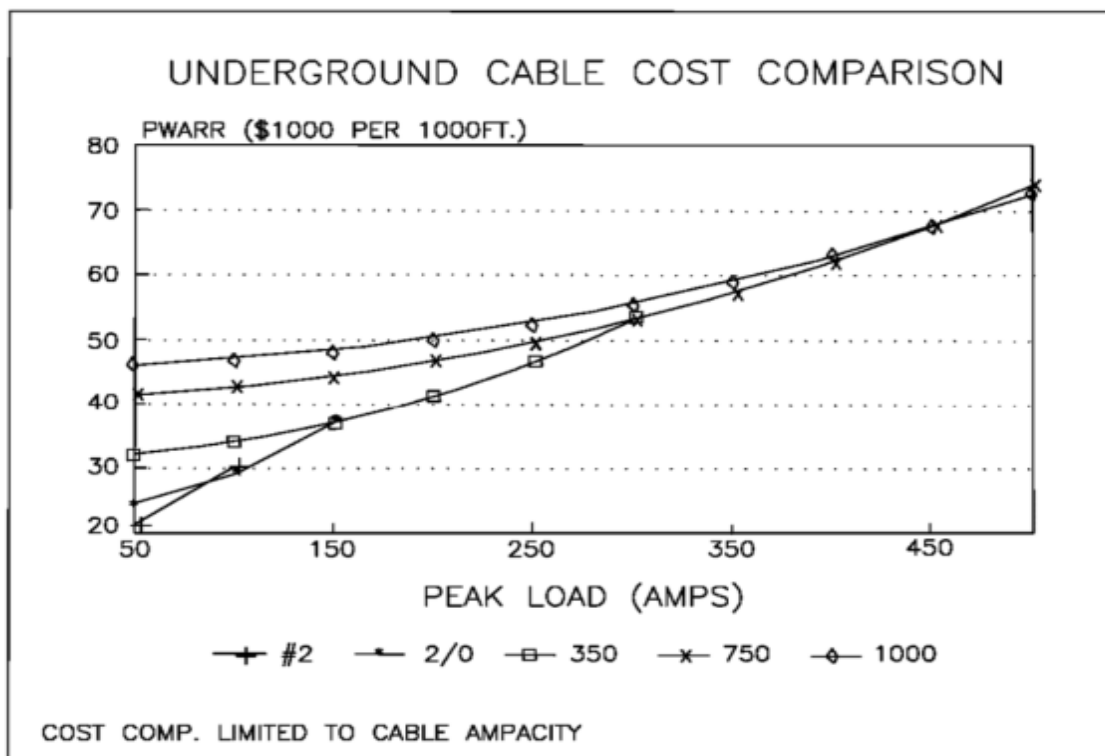
PURPOSE

This standard was prepared so District Engineering personnel would be able to select the least costly conductor size based on the amount of load which the conductor would serve. The graphs also make it possible for the district engineer to determine the cost penalty associated with installing a larger conductor than necessary to provide adequate tie capacity.

CRITERIA

The cost illustrated in the graphs below represent the PWARR to install 1000 feet of conductor plus the demand and energy charges associated with distribution system losses. In addition to the conductor cost the Underground Cable Cost Comparison includes the cost of connectors while the Overhead Conductor Cost Comparison includes the cost of poles, crossarms and anchors.

The graphs were constructed assuming the peak load is constant over the physical life of the conductor (20 years for UG, 30 years for OH). An average peak load to be expected over the life of the conductor must be calculated prior to using the graphs if the peak load is not constant (e.g. due to load growth, specific load additions, etc.).



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PRIMARY CONDUCTOR COST COMPARISON

FMO
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The following constants and assumptions were used to develop the graphs:

1. LACC UG = 16.7% OH = 16.13%
2. Physical Life UG = 20 yrs OH = 30 yrs
3. Energy Charge UG = 4.62¢/kWh OH = 5.44¢/kWh
4. Demand Charge UG = \$97.63/kW OH = 112.5/kW
5. Loss Factor = 0.25
6. Peak Responsibility Factor = 0.80
7. Construction Cost Contingencies = 20%
8. Underground Conductor Parameters:

3-1/c #2 PECN-PEJ	PWARR = \$18,042/1000'	R = .3339 ohms/1000'
3/c #2/0 PECN-PEJ	PWARR = \$22,656/1000'	R = .1663 ohms/1000'
3/c 350 XLPECN-PEJ	PWARR = \$31,504/1000'	R = .0649 ohms/1000'
3/c 750 XLPECN-PEJ	PWARR = \$41,225/1000'	R = .0345 ohms/1000'
3/c 1000 XLPECN-PEJ	PWARR = \$45,625/1000'	R = .0286 ohms/1000'
9. Overhead Conductor Parameters:

3/0 AWG ACSR/AW	PWARR = \$25,726/1000'	R = .1500 ohms/1000'
336 AWG ACSR/AW	PWARR = \$35,335/1000'	R = .0630 ohms/1000'
636 AWG ACSR/AW	PWARR = \$44,633/1000'	R = .0330 ohms/1000'
10. The book life, which is usually the physical life, is 28 years for UG cable and 36 years for OH conductor. PWARR figures used in this standard incorporated these book lives. However, the energy and demand charges used in this standard reflect historical conductor performance, 20 years for UG cable and 30 years for OH conductors.

The table below present the optimum conductor loading for each conductor size in tabular form:

Underground Cable Size Optimum Conductor Peak Loading

3-1/c #2	0 - 84 amps
3/c #2/0	85 - 151 amps
3/c 350	152 - 290 amps
3/c 750	291 - 445 amps
3/c 1000	> 445 amps

overhead Cable Size Optimum Conductor Peak Loading

3/0	0 - 151 amps
336	152 - 254 amps
636	> 254 amps

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		ECONOMIC EVALUATION OF ALTERNATIVES												

SCOPE

This standard provides a method of evaluating various alternatives so that the most economical one is identified. The advancement of an overload project to improve reliability is also discussed. For the latest calculation tools used to determine the present value of electric distribution projects, contact Distribution Planning.

PURPOSE

Present Worth of Annual Revenue Requirements (PWARR) has been selected by the Financial and Economic Analysis section as the appropriate analytical tool for distribution engineering projects. This is because it measures the total impact of a project on SDG&E's customers given the regulated environment of the utility.

DEFINITIONS

LACC (Levelized Annual Capital Cost) – A factor applied to the installed equipment costs to account for the annual levelized depreciation, return on investment, income taxes, property taxes and salvage.

A/P,n – Converts a present value into an annual series of payments over n years. Refer to the Economic Assumptions Manual, Table 2–1, for the current value.

P/A,n – Provides the present value of an annual series of payments made for n years. Refer to the Economic Assumption Manual, Table 2–1, for the current value.

P/F,n – Provides the present value of a future payment made n years from today. Refer to the Economic Assumption Manual, Table 2–1, for the current value.

Inflation Factor – Accounts for the rise in the price of goods and services over n years.

CRITERIA

The capital portion of Equation 1 below converts the equipment installed cost (Cost) into an annual series using the LACC Factor to account for taxes and return on investment. Then it sums all these payments into a present value at the time of construction using the P/A factor. In contrast, the O&M portion accounts for those non-capitalized expenditures which are included at the time of installation (O&M) and so the LACC and P/A factors are not applied.

$$PWARR = [(Inflation\ Factor)(P/F,n)][(Cost)(LACC)(P/A,n)+(O\&M)] \quad \text{Equation 1}$$

$$Inflation\ Factor = (1+i)^n \quad \text{Equation 2}$$

where: i = rate of inflation

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APPLICATION

PWARR analysis is used to compare alternative construction projects economically. Normally there are benefits associated with each project which have not been assigned a dollar amount and, therefore have not been considered. When the PWARR of one alternative is within 5 percent of another alternative it is appropriate to consider unassigned benefits (i.e. improvements in customer service, sensitivity to changes in input variables, lowest installed cost, etc.) in the decision.

A typical application of the PWARR analysis is shown in Example 1. It considers delaying the construction of a new circuit for two years by increasing tie capacity, thus allowing a load transfer to occur. The alternative is to construct the new circuit next year. Although the lives of the two alternatives are not the same (one ends in 28 years, the other 30), the Finance and Economic Analysis section feels Equation 1 provides a good approximation provided the difference in lives does not exceed 5 years.

Example 1

One feeder in a 4-EB5" duct is rated at 475 amps but has a projected load of 500 amps next year. To eliminate the projected overload consider shedding 100 amps to an adjacent circuit by constructing a tie next year for \$75k. This will delay having to construct a new circuit, at a cost of \$450k for an additional 2 years. The alternative is to construct the new circuit next year. Which alternative is the least costly considering all costs were provided in next year's dollars?

The following factors were obtained from the economic Assumptions Manual:

$$\begin{aligned} \text{LACC} &= 0.167, \text{ FERC account E367 (book life} = 28 \text{ yrs)} \\ \text{P/A, } 28 &= 8.2217 \\ \text{P/F, } 2 &= 0.8029 \\ \text{A/P, } 2 &= 0.5886 \\ i &= 5\% \end{aligned}$$

ALTERNATIVE 1: Construct a tie next year and defer the new circuit 2 years.

$$\text{Inflation Factor} = (1.05)^2 = 1.1025$$

$$\text{Construct tie PWARR} = (75k)(0.167)(8.2217) = \$102,976$$

$$\begin{aligned} \text{Construct circuit 2 yrs later PWARR} &= (1.1025)(.8029)(450k)(0.167)(8.2217) \\ &= \$546,929 \end{aligned}$$

$$\text{Total Cost } \$649,905$$

ALTERNATIVE 2:

$$\text{Construct circuit next year PWARR} = (450k)(0.167)(8.2217) = \$617,861$$

Conclusion Alternative 2 is approximately 5% less expensive and it should be selected unless there are sufficient unassigned benefits to favor alternative 1.

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Example 2

Consider advancing the construction of a new circuit 2 years to achieve an annual reliability benefit of \$100,000. The circuit cost is the same as in Example 1. Is this cost effective?

$$\text{Construct line next year} - (450k)(0.167)(8.2217) = \$617,861$$

$$\text{Construct line 2 yrs later} - (1.1025)(0.8029)(450k)(0.167)(8.2217) = \$546,929$$

$$\text{PWARR of advancement} = 617,861 - 546,929 = \$70,932$$

$$\text{C/B ratio} = (70,929)(A/P_2)/100,000 = 0.4175$$

Conclusion: It is cost effective to move the project ahead 2 years.

Example 3

Consider the effect of adding O&M expenditures to the construction in Example 1. O&M associated with constructing the new line is \$75k, \$15k for constructing the tie.

ALTERNATIVE 1:

$$\text{Construct tie line next year} \quad \text{PWARR} = \$102,976 + \$15,000 = \$117,976$$

$$\text{Construct ckt 2 yrs later} \quad \text{PWARR} = \$546,929 = (75k)(1.1025)(.0829) = \$613,319$$

$$\text{Total cost} = \$731,295$$

ALTERNATIVE 2:

$$\text{Construct new circuit next year} \quad \text{PWARR} = \$617,861 + \$75,000 = \$692,861$$

Conclusion: Alternative 2 is still approximately 5% less expensive and should be selected unless there are sufficient unassigned benefits to favor alternative 1.

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6321	DISTRIBUTION SUBSTATION RELIABILITY CRITERIA

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FMO
DM6301.1

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TABLE 1

Distribution Substation Transformer Loading Guide

Nameplate Rating Of Each Bank MVA	Number of Transformer Banks In Substation	Nameplate Capacity (MVA)	Firm Substation Peak MVA Load ① Summer(adverse)/ Winter	W/in 15 min. Immediate Load Shed MVA Level ② Summer(normal)/ Winter	W/in 4 Hrs Secondary Load Shed MVA Level ③ Summer(normal)/ Winter	Maximum Sustained Load on Any ④ Transformer (Summer/Winter %)
6/7.5	1	7.5	8.5/9.5	-	-	113/127
	2	15	17/19	11/13	8.5/9.5	147/173
	3	22.5	25.5/28.5	21/15	17/19	140/167
	4	30	34/38	30/37	26/29	133/164
10/12.5	1	12.5	14.5/17	-	-	116/136
	2	25	29/34	25/25	19/22	200/200

NOTES:

- ①
- Installation of additional transformer capacity is required at this MVA Load Level.
- ②
- When one transformer fails, load must be shed within 15 minutes to reduce loading to or below this MVA level.
- ③
- After transformer failure, substation load must be shed or transferred to this MVA level within four hours.
- ④
- This value is the maximum percent load at any time each of the remaining transformers for loss of a single transformer. In this context "sustained" means longer than momentary, i.e. longer than 5 minutes.

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PURPOSE

GUIDELINES FOR DISTRIBUTION SUBSTATION

Property purchased for a new 12kV distribution substation should be adequate for a total nominal capacity of 100, 75 or 50 MVA, using 15/20/25 (28) MVA transformers. Remote areas and special locations are exceptions. Selection of the substation property is discussed in Design Manual 6330, titled "Distribution Substation Siting Procedures". The ultimate one-line diagrams for 50, 75 and 100 MVA distribution substations are shown in the diagrams on page 6312.2 thru 6312.3. These diagrams are intended to guide the District Engineer in planning activities and not to dictate the actual substation design.

New 12kV circuit getaways will normally be underground. The standard getaway will be one run of 1000 kcmil aluminum cable. Overhead getaways may be installed at rural substations where only a few circuits are planned and area aesthetics are not materially affected. The number of circuits installed in a duct bank is dependent on the economics of reducing cable ampacity. Design Manual 5221, "Feeder Cable Ampacities Based on Thermal Loading Limits" provided guidance on determining cable ampacity.

All new 12kV substation are to be designed for compatibility with four-wire operation requirements according to Design Manual 6621, "Application of Primary Neutral". New circuit construction is to include installation of a neutral conductor.

All new 12kV substations are to be designed with an ultimate capacitor rating of 6 MVAR for each 28 MVA transformer bank. Substation capacitors for var load requirements should be installed in accordance with the "Capacitor Application Criteria", Design Manual 5811.

Substation equipment, unless acquired from existing stock, should ultimately conform to the following:

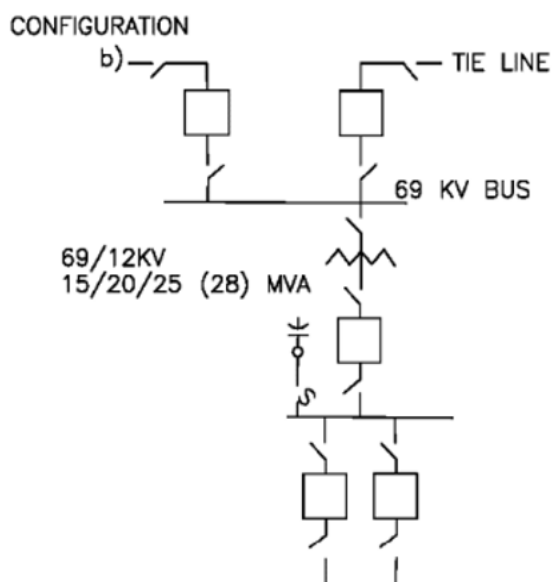
1. The 138kV and 69kV switchyard equipment will be rated as specified by transmission planning and will have minimum capacity sufficient to accommodate the ultimate load of the distribution substation.
2. The transformer bank will be three-phase, 15/20/25 MVA (55°C rise) and a top rating of 28 MVA (65°C rise). The cooling classes are ONAN/ONAF/ONAF. IEEE C57.12.00 ambient temperature conditions apply which allows for a 40°C Max ambient (considering an average of 30°C over 24-hour period). The transformers have LTCs which have $\pm$ ten percent adjustment on the low side voltage.
3. The 12kV switchyard will provide 2,000 amp main bus capacity with a 2,000 amp bus tie breaker. Low side transformer breaker positions will have a short time overload capability compatible with transformer loading Design Manual 6311. The 12kV feeder breakers will be rated 1,200 amps with an 18–20kA short circuit interrupting capability.
4. All new substations will include substation SCADA (status and control) in lieu of DPR equipment.

Typical ultimate equipment arrangements for distribution substations are shown on the following pages. Actual arrangements of new or existing substations may be planned differently depending on physical, economic, and reliability considerations.

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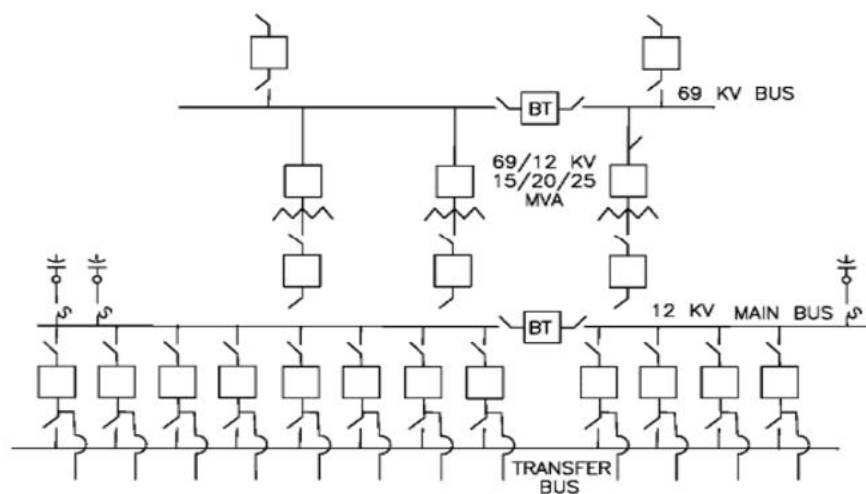


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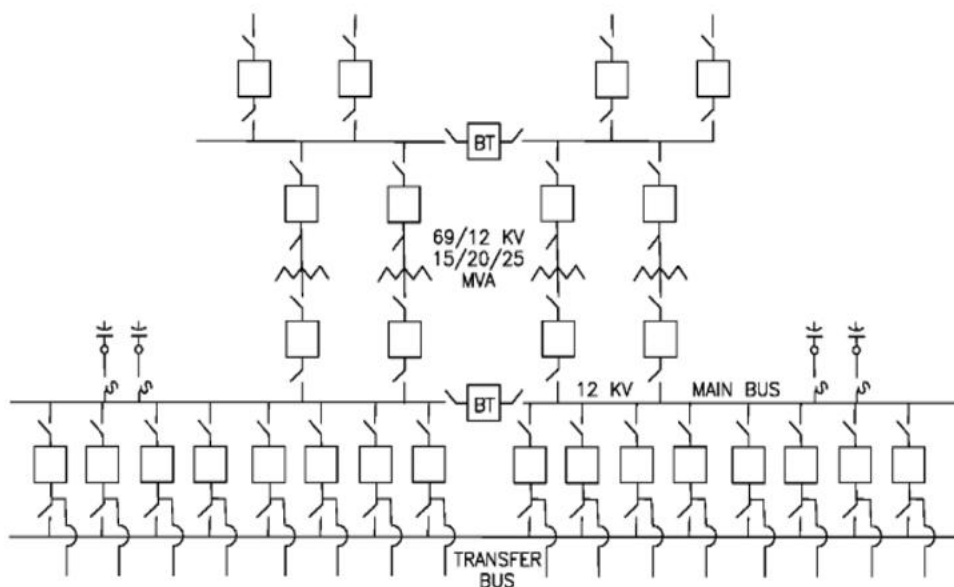
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H. Three Transformer Bank Substation



I. Four Transformer Bank Substation



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1. Maximum of 10,000 amp (symmetrical line-to-ground fault current).
2. Maximum of two units (transformers or gas turbines, each with impedance equivalent to or greater than ten percent on a 20 MVA base) paralleled per bus section during normal conditions.
3. Maximum of three units paralleled during contingency conditions (not to exceed 12 hours per occurrence).

Guideline B.1. requires the installation of neutral reactors at substations where line-to-ground fault currents are greater than the specified value. One neutral reactor per transformer will be provided during the development of the standard 100 MVA ultimate distribution substation. Distribution substations with gas turbine installations will also require neutral reactors for the gas turbine generators.

In order to meet the requirements of guideline B.3., relaying scheme will be provided which automatically closes the 12kV bus tie breaker following a transformer failure in a three or four bank substation. This procedure is required to obtain uniform loading and avoid dropping load immediately following a transformer failure.

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