

2026

ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

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Internal Version



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- 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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Tool Catalog	Roy Guilao	rguilao@sdge.com	(760) 672-6211

**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**

PAGE

SUBJECT

5223

SINGLE FAMILY RESIDENTIAL SECONDARY SYSTEMS

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DM5223 FIELD MAINTENANCE ONLY

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REVISION HISTORY:

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	SINGLE FAMILY RESIDENTIAL SECONDARY SYSTEMS				

SCOPE

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.

PURPOSE

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

DEFINITIONS

NONE

OPTIMUM ARRAY TABLE APPLICATION

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:

1. Determine KW Demand

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

2. Determining Secondary Distance

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.

3. Determining Service Distance


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).

4. Selecting Optimum Arrays

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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- a. 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.
- b. 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.
- c. Listed below are the double-sided array, long service, and corresponding short service distances.
- d. The arrays are symmetrical about the transformer unless a note to the contrary is shown.

Double-sided array

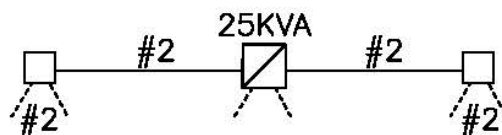
Long Service	Short Service
150'	50'
140'	50'
130'	50'
120'	40'
110'	40'
100'	30'
90'	30'
80'	20'

- 5. 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. 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.
 - b. 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.

- 1. 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.



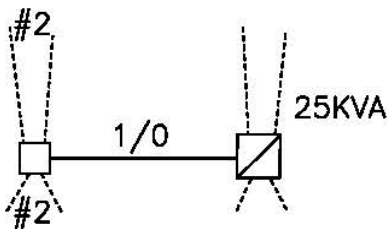
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SINGLE FAMILY RESIDENTIAL SECONDARY SYSTEMS					

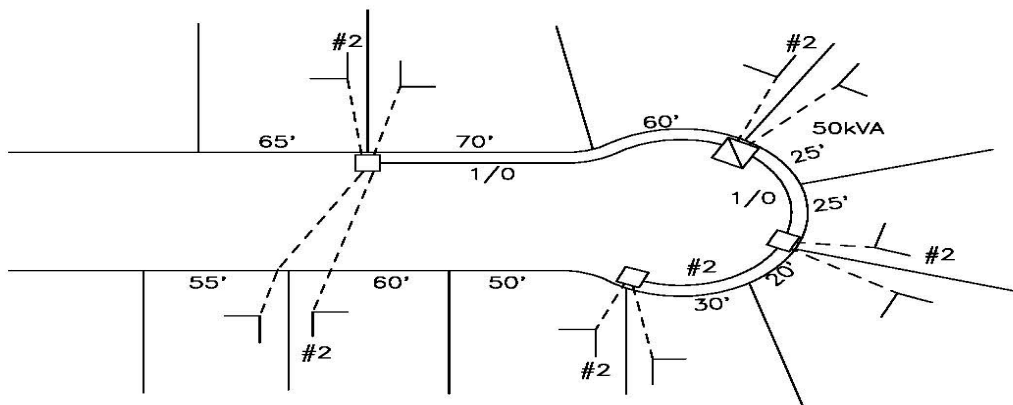
Select the double-sided optimum array for the subdivision described in Example 1 having a 90' long service (50' wide streets).

- 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'.

- 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

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

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

**SINGLE FAMILY RESIDENTIAL
SECONDARY SYSTEMS**

FMO
DM5223.3



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	#2-#2	10	60-70	20-50	1/0-1/0	10	80	20	3/0-1/0-1/0	14	60-80	20-80	1/0-#2	8(a)	80	40-50	1/0-1/0	8(a)(a)
90	20-30	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	20-30	1/0-#2	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(a)	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	6	80	50	1/0	6
				130	20-40	1/0	6	130	50	1/0	6	100	20-50	1/0	6	90	20-50	1/0	6
				130	50	1/0	6	140-150	20-40	1/0	6	100	50	1/0	6(f)	100	50	1/0	6(f)
				140-150	20-40	1/0	6	140-150	50	1/0	6	110	20-30	1/0	6	110	20-30	1/0	6
				140-150	50	1/0	6(f)					110	40-50	1/0	6(f)	110	40-50	1/0	6(f)
												120	20-30	1/0	6	120	20-30	1/0	6
												120	40	1/0	6(f)	120	40	1/0	6(f)
												120	50	3/0	6	120	50	3/0	6
												130	20	1/0	6	130	20	1/0	6
												130	30	1/0	6(f)	130	30	1/0	6(f)
												130	40-50	3/0	6	130	40-50	3/0	6
												140	20	1/0	6(f)	140	20	1/0	6(f)
												140	30-50	3/0	6	140	30-50	3/0	6
												150	20	1/0	6(f)	150	20	1/0	6(f)
												150	30-40	3/0	6	150	30-40	3/0	6
												150	50	3/0	6(f)	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	80110	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(g)(t)	60	120-150	3/0-3/0	20(e)	70	80-150	3/0-1/0	20(e)	80	90-120	3/0-1/0	20(e)	
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(e)	
				70	110-150	3/0-3/0	18(g)(t)	70	90-100	3/0-3/0	20(e)	80	120	3/0-3/0	18(f)	80	150	3/0-3/0	20(e)	
90	150	#2	8	80	80-90	1/0	12	70	110	1/0	12	90	80	3/0-3/0	20(e)	70	80-120	3/0-1/0	20(e)	
100	80-150	#2	8	80	100-130	3/0-3/0	18(g)(t)	80	80-100	3/0-3/0	20(e)		70	130	3/0-3/0	18(f)	70	130	3/0-3/0	20(e)
110	80-130	#2	8	80	140-150	3/0	12(f)	80	110	1/0	12	80	130-150	1/0	6	70	140-150	3/0-3/0	20(e)	
110	140-150	1/0	8	90	80-90	1/0	12		50KVA		80	90-150	1/0	6	80	80-100	3/0-1/0	20(e)		
120	80-90	#2	8	90	100-150	1/0	12(f)	70	120-150	1/0	12	100-110	80-150	1/0	6	80	110-130	3/0-3/0	20(e)	
120	100-150	1/0	8	100	80	1/0	12	80	120-140	1/0	12	120	80-130	1/0	6	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(e)	130	140-150	1/0	8(c)	90	80-120	3/0-1/0	20(e)	
120	100-150	1/0	8	100	140-150	3/0	12(f)	90	80-120	1/0	12	130	80-100	1/0	6	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(e)	
				110	140-180	3/0	12(f)	100	80-110	1/0	12	140	80-90	1/0	6	100	90-110	3/0-3/0	20(e)	
				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	16(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)	
																150	130-150	3/0	12(n)	
																150	80-120	3/0	12(f)	

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

SINGLE FAMILY RESIDENTIAL

SECONDARY SYSTEMS

Sq. Ft.: 2000-2999 SINGLE-SIDED

4.5kW Base Load (BL)				7kW Air Conditioning (A/C)				7kW Electric Water Heater (EWH)				8kW Electric Heater(EH)				4.5kW 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-S3	# Cust	Sec Ft	Serv Ft	S1-S2-S3	# Cust
70-80	20-60	#2	10	80	20-40	3/0-1/0	10	80	20-50	1/0-1/0	10	80	20	3/0-1/0-1/0	14	80	20	3/0-3/0-1/0	14
90-100	20-50	1/0-#2	10	80	50	3/0-1/0	10(e)	70	20-40	1/0-1/0	10	80	30	3/0-1/0-1/0	12(u)	60	30	3/0-3/0-1/0	14(h)
120-150	20-50	1/0-1/0	10	70	20-50	3/0-3/0	10	70	50	1/0-1/0	10(e)	80	40-50	3/0-1/0-1/0	12(u)(b)	60	40-50	3/0-3/0-3/0	14(h)
	20-50	1/0-1/0	8	80	20-40	3/0-3/0	10	80	20-50	3/0-1/0	10	70	20-50	3/0-1/0-3/0	12(v)	70	20-30	3/0-3/0-3/0	14(h)
	20-50	#2	8	80	50	3/0-3/0	10	90	20-30	3/0-1/0	10			25kVA		70	40	1/0	8(f)
				80	80	3/0-3/0	10	80	40-50	3/0-1/0	10(e)	80-120	20-50	#2	6	70	50	3/0-1/0	10(e)
				80	40	3/0-3/0	10(e)	100	20-50	3/0-3/0	10	130	20-40	#2	6	80-90	50	3/0-3/0	10(e)
				80	50	3/0-3/0	10(e)	110	20-40	3/0-3/0	10	130	50	1/0	6	100-110	50	3/0-3/0	10(e)
				100	20	3/0-3/0	10	110	50	3/0-3/0	10(e)	140-150	20-50	1/0	6				
				100	30-40	3/0-3/0	10(e)	120	20-30	3/0-3/0	10								
				100	50	3/0-3/0	10(e)	120	40	3/0-3/0	8(t)								
								120	50	3/0-3/0	8(t)(a)								
				110	20-40	1/0	8	130-150	20-50	1/0	8					80	20	1/0	8
				110	50	3/0	8									80	30-40	1/0	8(f)
				120	20-30	1/0	8									90-100	20-40	1/0	8(f)
				120	40	1/0	8(f)									110	40	3/0	8
				120	50	3/0	8									120	20	3/0	8(f)
				130	20-30	1/0	8									120	30-40	3/0	8(f)
				130	40	1/0	8(f)									120	50	3/0	8(n)
				130	50	3/0	8									130	20	3/0	8
				140	20-30	1/0	8									130	30	3/0	8(f)
				140	40-50	3/0	8									130	40-50	3/0	8(n)
				150	20-40	3/0	8									140	20	3/0	8(f)
				150	50	3/0	8(f)									140	30-40	3/0	8(n)
																140	50	350	8
																150	20	3/0	8(f)
																150	30	3/0	8(n)
																150	40	350	8
																150	50	350	8(f)

DOUBLE-SIDED

4.5kW Base Load (BL)				7kW Air Conditioning (A/C)				7kW Electric Water Heater (EWH)				8kW Electric Heater(EH)				4.5kW 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-S3	# Cust
80-100	1/0-1/0	20	80	150	350-3/0	18(x)(a)	80	80	3/0-3/0	20(e)	80	80-110	3/0-3/0	20	60	80-110	3/0-1/0	20(e)	
110-150	3/0-1/0	20(e)	70	150	350-3/0	18(x)(a)	80	90-120	3/0-3/0	18(t)(f)	80	120-150	3/0-3/0	20(e)	60	110-150	3/0-3/0	20(a)	
80-100	1/0-1/0	20(e)	80	150	350-350	18(x)(a)	80	130	3/0-3/0	18(t)(f)	70	80	3/0-3/0	20	70	80-90	3/0-3/0	20(e)	
110-140	3/0-1/0	20	80	110-140	3/0-1/0	20	80	140-150	3/0-3/0	18(t)(f)	70	90-100	3/0-3/0	20(e)	70	100-150	3/0-3/0	20(a)	
150	3/0-1/0	20(e)	80	80-120	1/0	12(f)	70	80-120	3/0-3/0	18(t)(f)	70	110	1/0	12	80	80	3/0-3/0	20(e)	
80-110	3/0-1/0	20	80	130-140	3/0	12(f)	70	130	3/0-3/0	18(t)(k)	80	80-100	3/0-3/0	20(e)	80	90-130	3/0-1/0	20(a)	
120-150	3/0-1/0	20(e)	70	80	3/0	12	70	120-150	350-3/0	18(t)(g)	80	110	1/0	12	80	140-150	350-3/0	20(a)	
80-90	3/0-1/0	20(e)	70	80-140	3/0	12(f)	80	80-90	350-3/0	18(t)(g)	80				90	80	3/0-3/0	20(a)	
100-110	3/0-3/0	20	80	80	3/0	12	80	100-150	350-3/0	18(t)(g)	70				90	90-120	3/0-3/0	20(a)#	
80-110	3/0-3/0	20	80	90-130	3/0	12(f)	80				80	120-150	1/0	12	90	130-150	350-3/0	20(a)	
80			80	140	3/0	12(n)	90	80-100	1/0	12(f)	80	120-140	1/0	12	90	110	3/0-3/0	20(a)#	
90			80	80	3/0	12	80	110-120	3/0	12	90	80-120	1/0	12(f)	100	120-130	350-3/0	20(a)	
90-100	120-150	1/0	8	90	90-120	3/0	12(f)	90	130-150	3/0	12	90	130-150	1/0	12(f)	110	100-110	350-3/0	20(a)(n)
100-110	80-150	1/0	8	90	130-150	3/0	12(n)	100	80-100	3/0	12	100	80-110	1/0	12				
150	80-120	1/0	8	100	80-120	3/0	12(f)	100	110-150	3/0	12(f)	100	120-150	1/0	12	100	80-100	3/0	12(e)
130	130-150	1/0	8(c)	100	130-150	3/0	12(n)	110	80-90	3/0	12	110	80	1/0	12	100	140-150	3/0	12(e)
140	80-110	1/0	8	110	80-110	3/0	12(f)	110	80-150	3/0	12(f)	110	90-150	1/0	12(f)	110	80-90	3/0	12(e)
140	120-150	1/0	8(c)	110	120-150	3/0	12(n)	120	80	3/0	12	120	80-120	1/0	12	110	120-150	3/0	12(n)
150	80-100	3/0	8	120	80-100	3/0	12(f)	120	90-120	3/0	12(f)	120	130-150	3/0	12(f)	120	80-90	3/0	12(e)
150	110-150	3/0	8	120	110-150	3/0	12(n)	130	130-150	3/0	12(n)	130	80	1/0	12(f)	120	100-150	3/0	12(n)
				130	80-100	3/0	12(f)	130	80-110	3/0	12(f)	130	90-140	3/0	12	130	80-90	3/0	12(e)
				140	110-150	3/0	12(n)	130	120-150	3/0	12(n)	130	150	3/0	12(f)	130	100-140	3/0	12(n)
				140	80-90	3/0	12(f)	140	80-100	3/0	12(f)	140	80-120	3/0	12	130	150	350	8(f)
				140	100-140	3/0	12(n)	140	110-150	3/0	12(n)	140	130-150	3/0	12(f)	140	80-120	3/0	12(n)
				140	150	350	12(n)	150	80	3/0	12(f)	150	80-110	3/0	12	140	130-150	350	8(f)
				150	80-90	3/0	12(f)	150	90-150	3/0	12(n)	150	120-150	3/0	12(f)	150	80-110	3/0	12(n)#
				150	100-140	3/0	12(n)									150	120	350	8(f)
																150	130-150	350	8(f)

H2-H5 SHORT=1/0-1/0
H1-H4 SHORT=1/0-1/0

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-H5=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

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REV	CHANGE	BY	DSGN	APPV	DATE	REV	CHANGE	BY	DSGN	APPV	DATE
C						F					
B	FORMATTING	JIK	-	-	02/21/2020	E					
A	ORIGINAL ISSUE	-	CVN	RDG	01/01/1987	D					

SHEET
6 OF 7

Indicates Latest Revision

Completely Revised

New Page

Information Removed

FMO
DM5223.6

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SINGLE FAMILY RESIDENTIAL

SECONDARY SYSTEMS



Sq. Ft. 0-1299

Sq. Ft. 1300-1999

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

Sq. Ft. 2000-2999

SINGLE-SIDED

SINGLE-SIDED

SINGLE-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-S3	# 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
80	30	50kVA		60-70	20-50	1/0-1/0	10	80	20-30	1/0-1/0	10	80	20-40	3/0-1/0	10	80	20	1/0-1/0	10	80	20-40	3/0-1/0	10
80	30-50	3/0-3/0-1/0	14	80	20-50	1/0-1/0	10(e)	80	40-50	1/0-1/0	10(e)	80	20-50	3/0-3/0	10	80	30-50	3/0-1/0	10(e)	80	20-50	3/0-1/0	10(e)
80	20-50	1/0-1/0	10	80	20-50	3/0-1/0	10	80	20-50	3/0-1/0	10	80	20-50	3/0-3/0	10	80	20-50	3/0-1/0	10	80	20-50	3/0-1/0	10
80	20	3/0-1/0	10	80	30-50	3/0-1/0	10(e)	80-90	20-50	3/0-3/0	10	80	20-40	3/0-3/0	10	80	20-50	3/0-3/0	10	80	20-50	3/0-3/0	10
80	30-50	3/0-1/0	10	80	20	3/0-3/0	10	100	20	3/0-3/0	10	80	20-30	3/0-3/0	10	80	30-50	3/0-3/0	10(e)	80	20-40	3/0-3/0	10(e)
90-110	20-50	#2	6	100	30-50	3/0-3/0	10(e)	100	30-50	3/0-3/0	10(e)	90	40	3/0-3/0	10(e)	100	20	3/0-3/0	10	100	20	3/0-3/0	10
120-150	20-50	1/0	6	110	20-50	3/0-3/0	10(e)	110	20	3/0-3/0	10(e)	90	50	3/0-3/0	10(e)	100	30	3/0-3/0	8(e)(f)	80	40-50	3/0-3/0	10(e)
				120	50	3/0-3/0	8(e)	120-150	20-50	1/0	8	100	20	3/0-3/0	10(e)	100	40-50	3/0-3/0	8(e)(f)	80	50	3/0-3/0	10(e)
						25kVA						100	30-40	3/0-3/0	10(e)	100	20	3/0-3/0	10	100	20	3/0-3/0	10
				130	20-40	1/0	6					100	50	3/0-3/0	10(e)	100	30	3/0-3/0	10	100	30	3/0-3/0	10
				130	50	1/0	6					110	20-40	1/0	6	100	40	1/0	6	100	40	1/0	6
				140-150	20-40	1/0	6					120	40	1/0	6	110	20-30	1/0	6	110	20-30	1/0	6
				140-150	50	1/0	6					130	40	1/0	6	120	20-30	1/0	6	120	20-30	1/0	6
							8(f)					130	50	3/0	6	130	20	1/0	6	130	20	1/0	6
												140	20-30	1/0	6	130	30-40	1/0	6	130	30-40	1/0	6
												140	40	1/0	6	140	20	1/0	6	140	20	1/0	6
												150	20-40	3/0	6	140	30	3/0	6	140	30	3/0	6
												150	50	3/0	8(f)	140	40-50	3/0	6	140	40-50	3/0	6
																150	20	3/0	6	150	20	3/0	6
																150	30-40	3/0	6	150	30-40	3/0	6
																150	50	3/0	8(f)	150	50	3/0	8(f)

o)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=SS=1/0-#2, v)S4=SS=1/0-1/0, w)S2=SS=3/0-1/0, x)S4=3/0

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
60	80-90	3/0-3/0	20	60	80-100	3/0-3/0	16(e)(f)	60	80-100	3/0-3/0	16(f)(g)	60	150	350-3/0	16(x)(y)	80	80-100	3/0-3/0	16(f)(j)	80	80-80	3/0	12
80	100-150	3/0-3/0	20(e)	80	110-150	3/0-3/0	16(g)(h)	80	100-120	3/0-3/0	16(h)(i)	70	150	350-3/0	16(y)(z)	80	110	3/0-3/0	16(f)(k)	80	100-140	3/0	12(f)
70	80-100	3/0-3/0	20(e)	70	80-100	1/0	12	80	130-150	3/0-3/0	16(i)(l)	80	150	350-350	16(z)(aa)	80	120-140	350-3/0	16(f)(m)	80	150	350-3/0	20(a)
		50kVA		70	110-150	350-3/0	16(g)(n)	70	80	3/0-3/0	16(f)(o)	80	150	350-3/0	16(aa)(ab)	80	150	350-3/0	16(f)(p)	80	80	3/0	12
70	110-150	1/0	12	80	80-90	1/0	12	70	90	350-3/0	16(f)(q)	80	80-120	1/0	12(f)	70	80	350-3/0	16(f)(r)	70	90-140	3/0	12(f)
80	80-110	1/0	12	80	100-130	350-3/0	16(g)(s)	70	100-150	350-3/0	16(h)(t)	80	130-140	3/0	12(f)	70	90-120	350-3/0	16(f)(u)	70	150	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(i)(v)	70	80	3/0	12	70	130-140	350-3/0	16(f)(w)	80	80	3/0	12
90	80-100	1/0	12	90	80-90	1/0	12	80	120-140	350-3/0	16(j)(x)	70	90-140	3/0	12(f)	80	150	350-3/0	16(f)(y)	80	90-130	3/0	12(f)
90	110-150	1/0	12(f)	90	100-150	1/0	12(f)			50kVA		80	80	3/0	12	70	150	3/0	12(f)	80	140-150	3/0	12(f)
100	80-150	1/0	12	100	80-130	1/0	12	80	150	3/0	12(f)	80	90-130	3/0	12(f)	80	80-100	3/0	12(f)	80	80	3/0	12
110	80-110	1/0	12(f)	100	140-150	3/0	12(f)	80	80-90	3/0	12	80	80-100	3/0	12(f)	80	110-150	3/0	12(f)	80	90-120	3/0	12(f)
110	120-140	3/0	12	100	140-150	3/0	12(f)	90	100	100	12(f)	80	100-140	3/0	12(f)	80	130-150	3/0	12(f)	80	130-150	3/0	12(f)
120	80-110	3/0	12	110	80-130	1/0	12(f)	90	80-110	3/0	12	90	130-150	3/0	12(f)	100	80-120	3/0	12(f)	100	80-120	3/0	12(f)
120	120-150	3/0	12(f)	110	140-150	3/0	12(f)	100	110-150	3/0	12	100	130-150	3/0	12(f)	100	100-140	3/0	12(f)	100	80-120	3/0	12(f)
130	80-110	3/0	12	120	80-110	1/0	12(f)	110	80-130	3/0	12(f)	100	150	3/0	8(e)	100	80-110	3/0	12(f)	110	110-150	3/0	12(f)
130	120-150	3/0	12(f)	120	120-140	3/0	12(f)	110	140-150	3/0	8(e)	110	80-110	3/0	12(f)	100	90-140	3/0	12(f)	110	120-150	3/0	12(f)
140	80-100	3/0	12	130	100-130	3/0	12	120	120-150	3/0	12(f)	110	120-150	3/0	12(f)	110	120	3/0	12(f)	110	120-150	3/0	12(f)
140	100-150	3/0	12(f)	130	140-150	3/0	12(f)	120	80-110	3/0	8(e)	120	80-100	3/0	12(f)	110	130-150	3/0	12(f)	110	80-100	3/0	12(f)
150	80-90	3/0	12	140	100-130	3/0	12(f)	130	80	3/0	12(f)	130	110-150	3/0	12(f)	120	100	3/0	8(e)	120	110-150	3/0	12(f)
150	100-150	3/0	12(f)	140	140-150	3/0	12(f)	130	100-130	3/0	8(e)	130	110-150	3/0	12(f)	120	80-90	3/0	8(e)	120	110-150	3/0	12(f)
				150	80-90	3/0	12(f)	140	140-150	3/0	12(f)	140	80-80	3/0	12(f)	130	130-150	3/0	8(e)	130	80	350	12
				150	100-120	3/0	12(f)	140	80	3/0	12(f)	140	100-140	3/0	12(f)	130	150	3/0	8(e)	130	90-130	350	12(f)
				150	130-150	3/0	12(n)	140	120	3/0	12(f)	150	80-80	3/0	12(f)	140	80	350	8(e)	140	150	350	12(f)
								140	130-150	3/0	9(r)	150	100-140	3/0	12(f)	150	80-100	3/0	8(e)	150	140-150	350	8(f)

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REV	CHANGE	BY	DSGN	APPV	DATE	REV	CHANGE	BY	DSGN	APPV	DATE
C						F					
B	FORMATTING	JIK	-	-	02/21/2020	E					
A	ORIGINAL ISSUE	-	CVN	RDG	01/01/1987	D					

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New Page

Information Removed

FMO
DM5223.7

SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY

SINGLE FAMILY RESIDENTIAL

SECONDARY SYSTEMS

5300
DEMAND
ESTIMATING

5300
DEMAND
ESTIMATING

5300 - No FMO standards for this section.

5400
VOLTAGE DROP

5400
VOLTAGE DROP

PAGE

SUBJECT

5431

UNDERGROUND VOLTAGE DROP AND FLICKER NOMOGRAPH

5432

OVERHEAD VOLTAGE DROP AND FLICKER NOMOGRAPH

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REV	CHANGE	DR	BY	DSN	APV	DATE	REV	CHANGE	DR	BY	DSN	APV	DATE
C							F						
B							E						
A	5431 AND 5432 MOVED TO FMO	YZZ	FRC	FRC	FRC	11/06/2025	D						

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FOR FIELD MAINTENANCE ONLY

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VOLTAGE DROP**

**FMO
DM5401.1**

DM5431 FIELD MAINTENANCE ONLY

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

REVISION HISTORY:

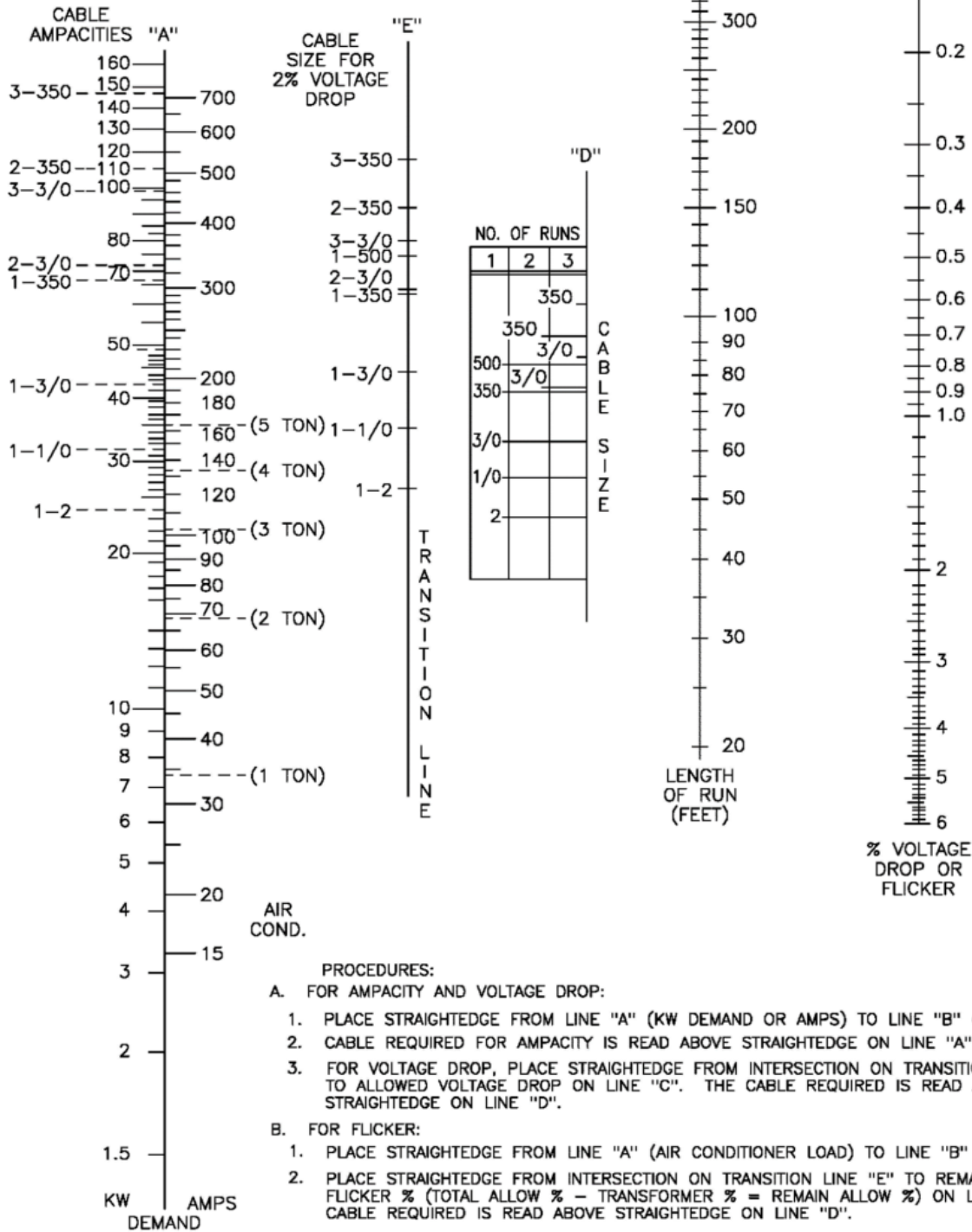
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	UNDERGROUND VOLTAGE DROP AND FLICKER NOMOGRAPH				

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



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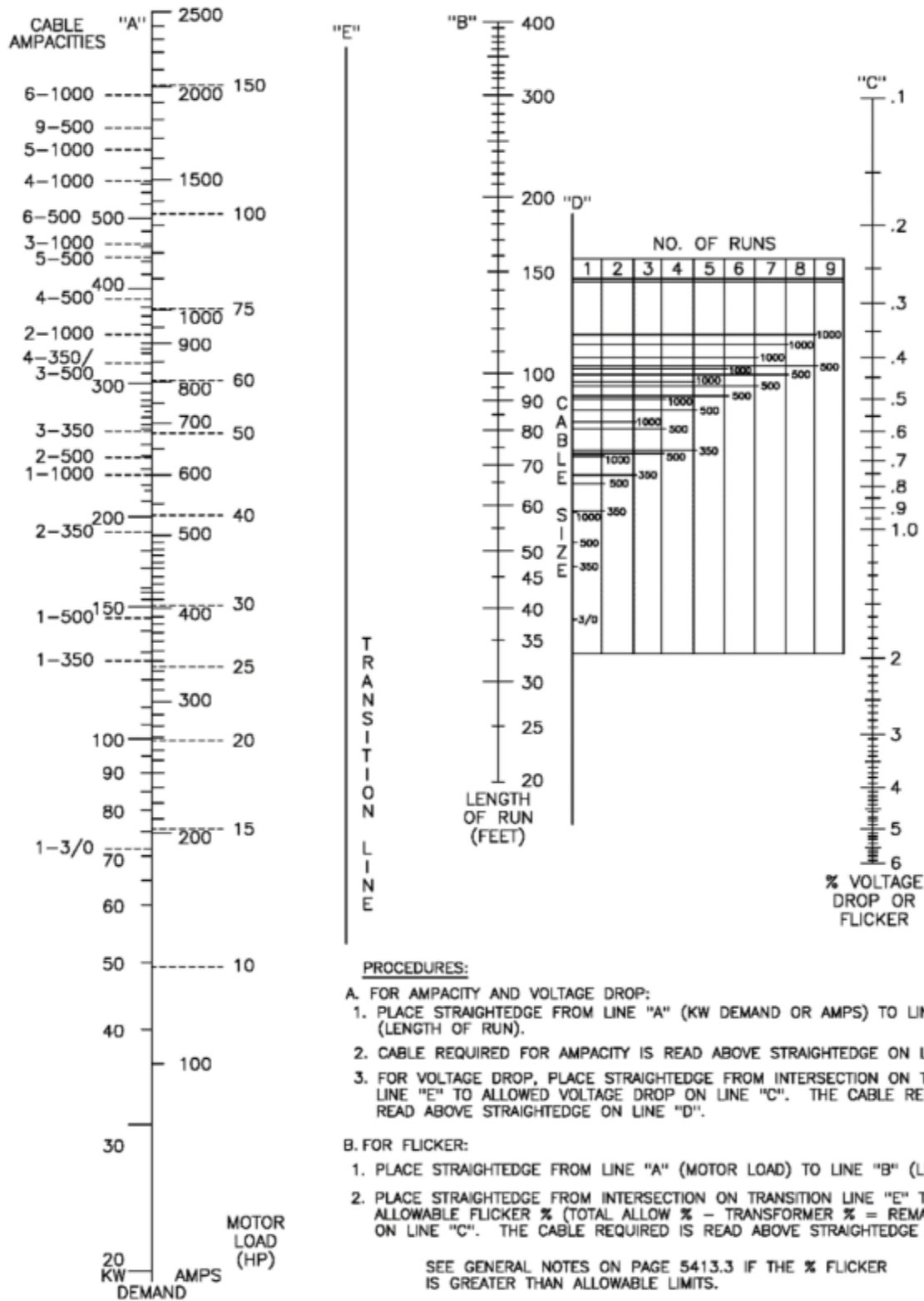
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SHEET
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SINGLE-PHASE 120/240V UNDERGROUND VOLTAGE DROP
AND FLICKER NOMOGRAPH

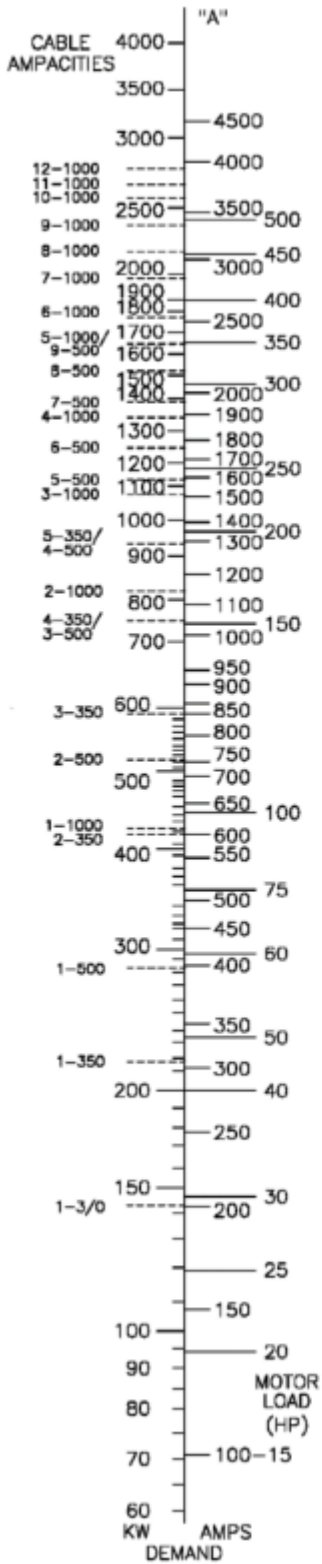
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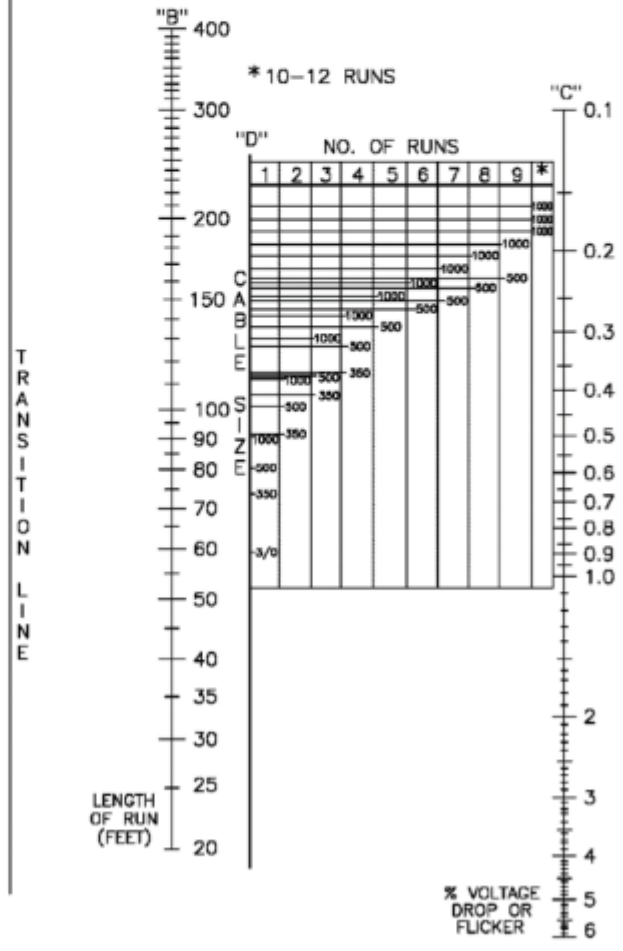
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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY				
	3Ø 120/240V UNDERGROUND VOLTAGE DROP AND FLICKER NOMOGRAPH				



- 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.
1. FOR FLICKER: 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.



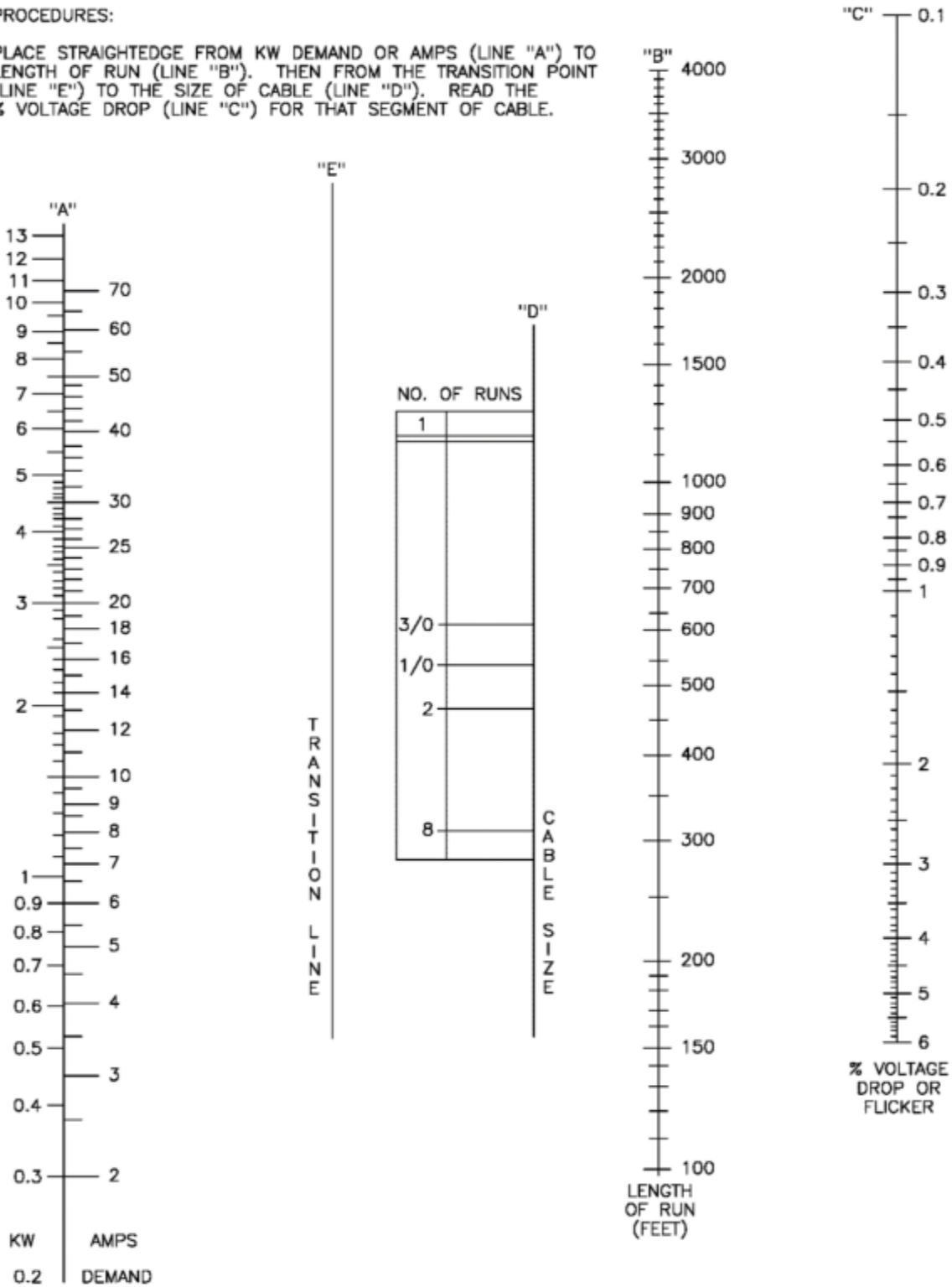
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	3Ø 277/480Y UNDERGROUND NOMOGRAPH				

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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SHEET
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SINGLE-PHASE 120/240V UNDERGROUND
STREET LIGHT NOMOGRAPH

FMO
DM5431.5

DM5432 FIELD MAINTENANCE ONLY

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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:

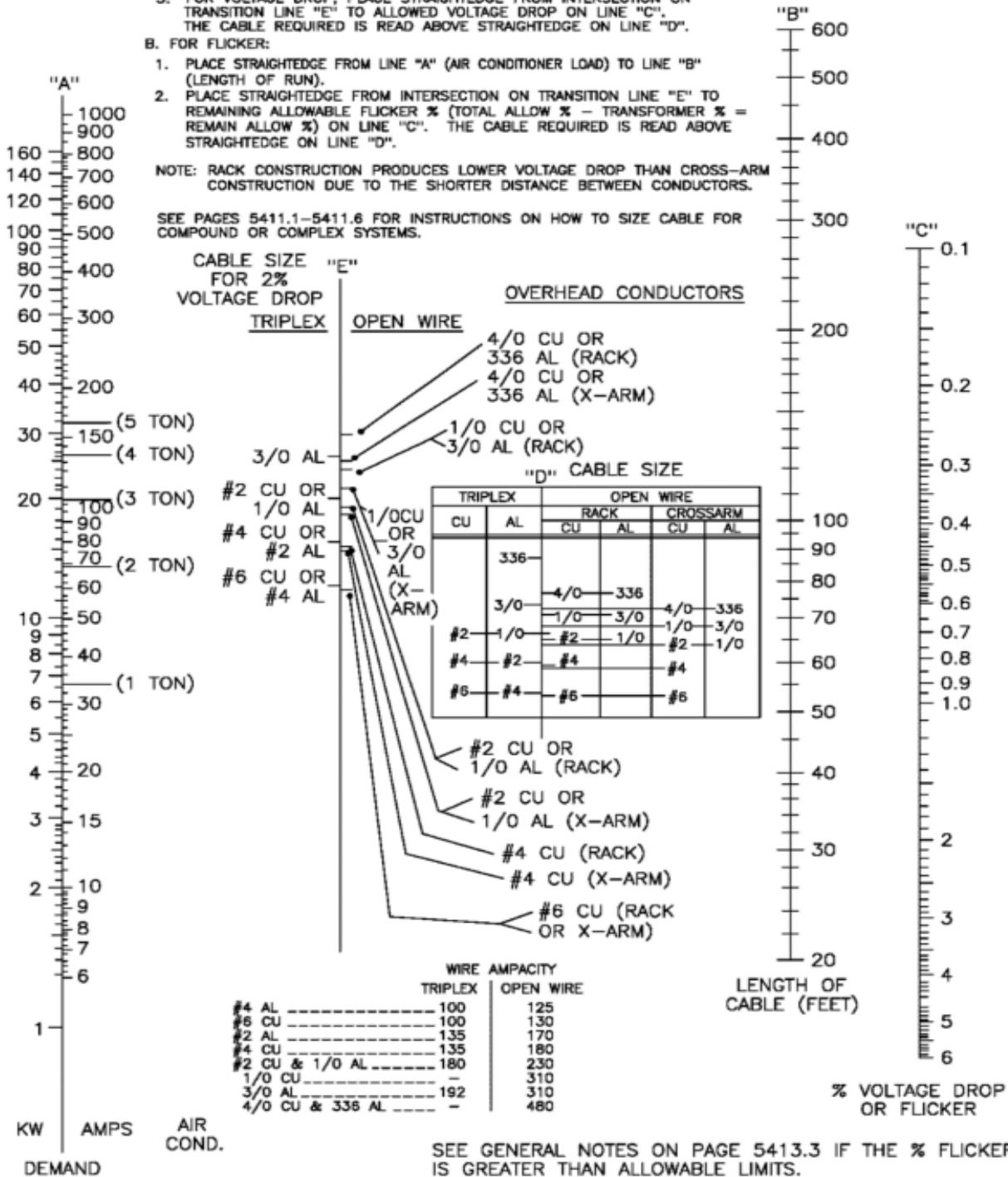
1. PLACE STRAIGHTEDGE FROM LINE "A" (KW DEMAND OR AMPS) TO LINE "B" (LENGTH OF RUN).
2. WIRE REQUIRED FOR AMPACITY IS READ OFF TABLE BELOW.
3. FOR VOLTAGE DROP, PLACE STRAIGHTEDGE FROM INTERSECTION ON TRANSITION LINE "E" TO ALLOWED VOLTAGE DROP ON LINE "C". THE CABLE REQUIRED IS READ ABOVE STRAIGHTEDGE 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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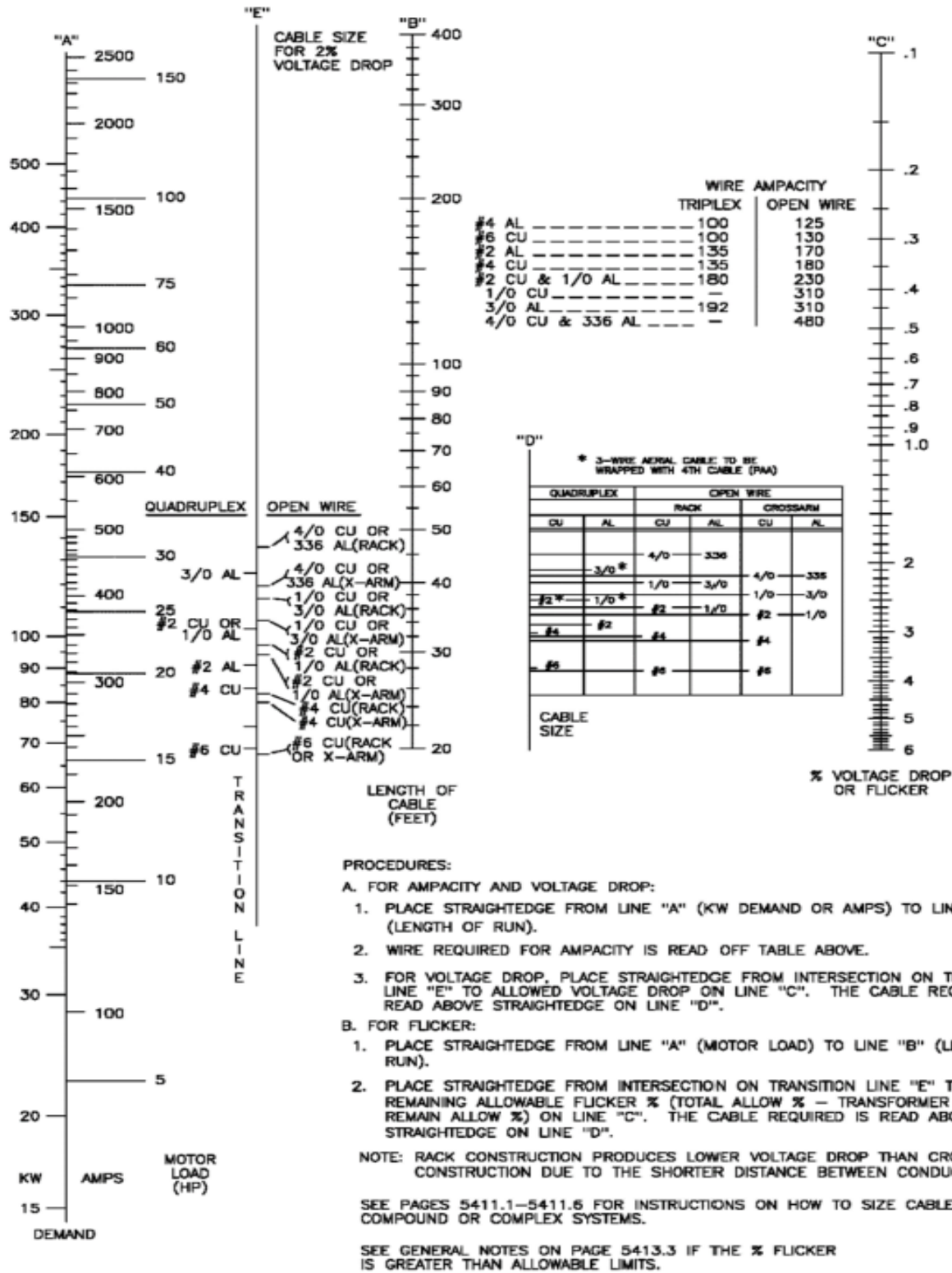
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SHEET
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SINGLE-PHASE 120/240V OVERHEAD VOLTAGE DROP
AND FLICKER NOMOGRAPH

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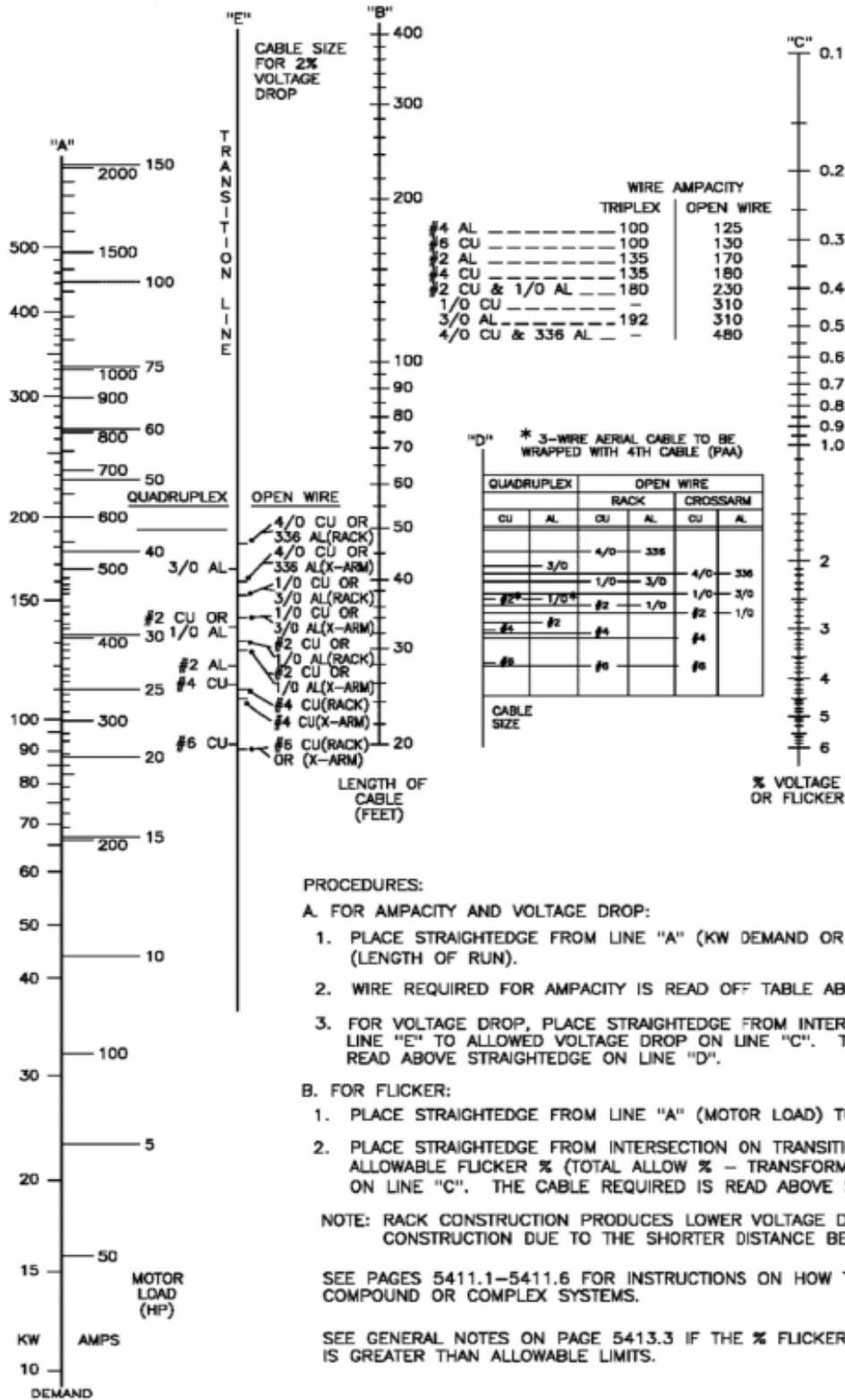
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THREE PHASE 120/208Y OVERHEAD VOLTAGE DROP
AND FLICKER NOMOGRAPH

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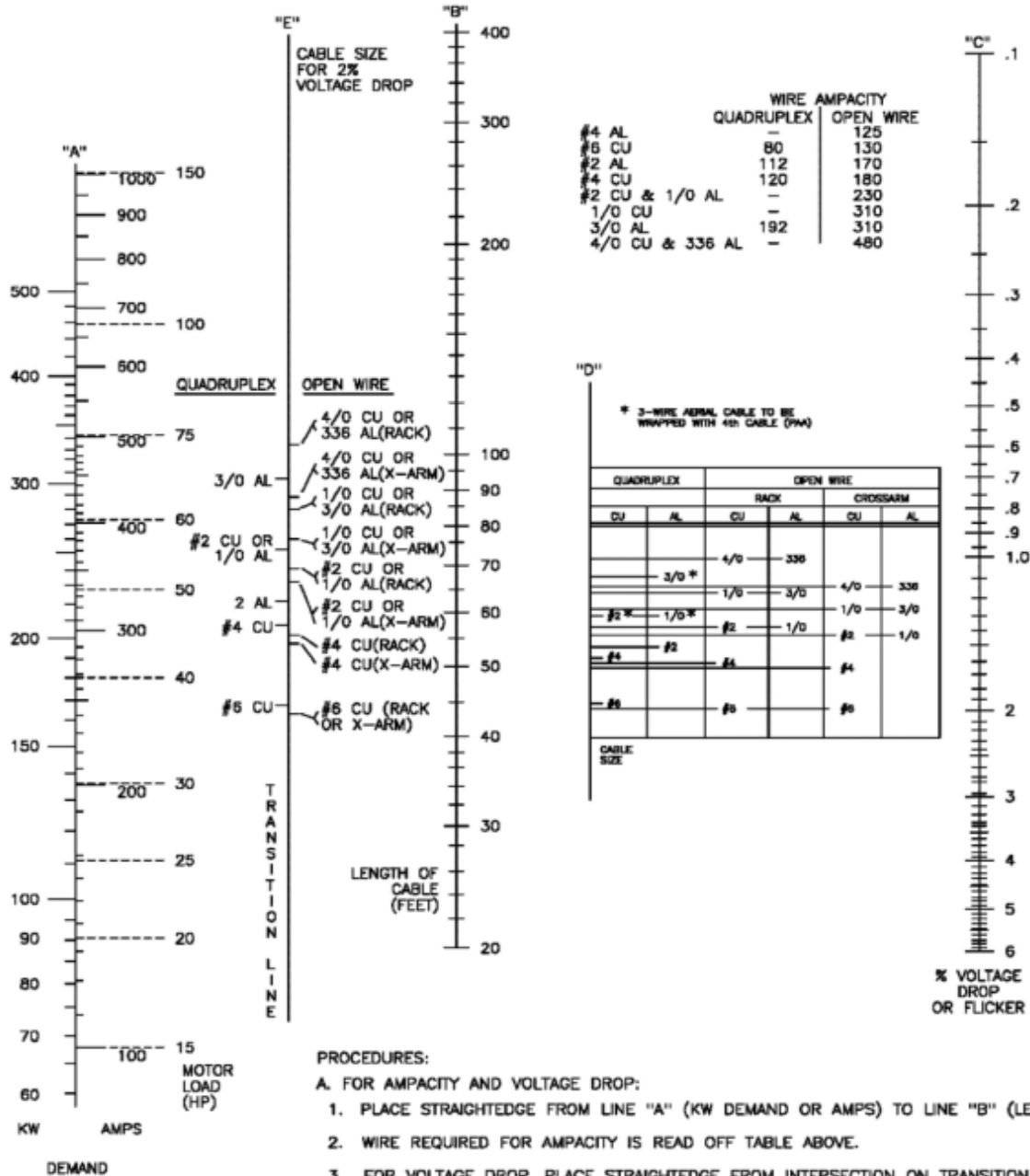
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SHEET
3 OF 4

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

FMO
DM5432.3



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 ABOVE.

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"

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

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

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**

5700 - No FMO standards for this section.

5800
CAPACITORS

5800
CAPACITORS

5800 - No FMO standards for this section.

5900
WIRE & SUPPORTS

5900
WIRE & SUPPORTS

5900 - No FMO standards for this section.

**6000
SUBSTATION
LOAD FORECASTING**

**6000
SUBSTATION
LOAD FORECASTING**

6000 - No FMO standards for this section.

6100
SECTIONALIZING
& PROTECTION

6100
SECTIONALIZING
& PROTECTION

PAGE

SUBJECT

6114

UNDERGROUND SERVICE RESTORER

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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 PECC 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.

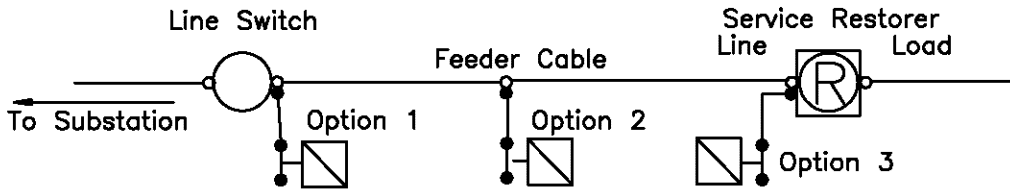
1. 600A Padmounted Service Restorer
 - a. Consideration must be made regarding the location and length of the unfused cable segments when locating the service restorer. As a general guide, locate the service to maximize the amount of load on the line side of the device and to maximize the circuit length 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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APPD JCE / <i>VCE</i>				

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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	UNDERGROUND SERVICE RESTORER APPLICATION CRITERIA			DATE 1-1-94 APPD MF/ROJ

**6200
SYSTEM
ENGINEERING**

**6200
SYSTEM
ENGINEERING**

PAGE

SUBJECT

6213 TRANSFORMER PRIMARY VOLTAGE SELECTION

6222 APPLICATION OF GROUNDING BANKS

6242 ECONOMIC EVALUATION OF ALTERNATIVES

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B	6242 MOVED TO FMO	YZZ	FRC	FRC	FRC	07/18/2025	E						
A	6222 MOVED TO FMO	JIK	FRC	FRC	KRG	09/16/2024	D						

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TRANSFORMER PRIMARY VOLTAGE SELECTION						

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				

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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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY				
	APPLICATION OF GROUNDING BANKS				

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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DM6242 FIELD MAINTENANCE ONLY

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	SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL FIELD MAINTENANCE ONLY						
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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SUBSTATION
ENGINEERING**

**6300
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