2026
ELECTRIC DISTRIBUTION DESIGN MANUAL

Historical Record: 08/21/2026
External Version

SDGE™

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DISTRIBUTION SYSTEM DESIGN MANUAL

INTRODUCTION

The Design Manual is a technical reference intended for use by customer project planners and engineers. The design and planning standards described within the manual have been developed through the joint efforts of line and staff personnel. The objective has always been to identify and document consistent and cost effective criteria and procedures for designing and planning the electric distribution system. The general contents of the manual are, therefore, to be considered standards, not guidelines. And all system designs and expansion plans should be developed in accordance with them, when technically and economically feasible. Application of the Design Manual in this spirit will help to assure uniform design practices and consistent levels of service reliability among the different districts.

Michael J. Coburn
Manager
Electric Distribution Engineering

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ATTENTION:

THESE STANDARDS WERE DEVELOPED FOR MAINTAINING SAFETY AND RELIABILITY OF THE ELECTRIC DISTRIBUTION AND SERVICE SYSTEMS.

THE INTENT OF THIS STANDARD IS TO GUIDE ENGINEERS, DESIGNERS/PLANNERS AND CONSTRUCTION PERSONNEL AND PROVIDE TYPICAL CONSTRUCTION METHODS FOR ELECTRIC DISTRIBUTION. NOT ALL ARRANGEMENTS ARE DEPICTED AND IT IS THE USER'S RESPONSIBILITY TO APPLY THESE STANDARDS APPROPRIATELY. ALL USERS MUST USE GOOD JUDGMENT. STANDARDS ARE UPDATED AS NEEDED. CONSULT EDE FOR LATEST VERSION. SDG&E STANDARDS MUST BE APPLIED. PRE-CONSTRUCTION APPROVAL OF A "DEVIATION REQUEST" IS REQUIRED FOR ANY EXCEPTION TO THESE STANDARDS. ANY ALTERATIONS, MODIFICATIONS OR IMPROVEMENTS TO THIS AND ALL STANDARDS MUST BE REVIEWED, APPROVED AND DOCUMENTED BY EDE-CONSTRUCTION STANDARDS AND DISTRICT C&O'S.

THE CPUC'S GENERAL ORDER 95 RULES/REQUIREMENTS ARE NOT INTENDED FOR USE AS COMPLETE CONSTRUCTION SPECIFICATIONS BUT EMPLOY ONLY THE MINUMUM REQUIREMENTS WHICH ARE MOST IMPORTANT FROM THE STANDPOINT OF **SAFETY AND RELIABILITY.** SDG&E MAY IMPOSE STRICTER RULES AND REQUIREMENT IN THE INTREST MAINTANANING SAFETY AND RELIABILTY OF OUR ELECTRICAL SYSTEM.

CONSTRUCTION SHALL BE ACCORDING TO ACCEPTED GOOD PRACTICE FOR GIVEN LOCAL CONDITIONS IN ALL SITUATIONS NOT SPECIFIED IN THE STANDARD.

SDG&E WILL NOT ACCEPT ANY SYSTEM DESIGN OR INSTALLATION WHICH DOES NOT CONFORM TO THESE STANDARDS

DEVIATIONS CANNOT BE GRANTED WHICH CONFLICT WITH THE CPUC GENERAL ORDERS OR OTHER GOVERNING AGENCIES. THESE MAY INCLUDE SEPARATION FROM ENERGIZED FACILITIES AND WORKING CLEARANCES.

BASED ON UNUSUAL OR UNSAFE SITE CONDITIONS SDG&E MAY IN THE INTEREST OF SAFETY OR RELIABILITY REQUIRE CONSTRUCTION MEASURES BEYOND THOSE SPECIFICALLY STATED IN THIS MANUAL.

EXCEPT FOR A REQUIREMENT TO IMMEDIATELY ADOPT NEWLY PUBLISHED STANDARDS, THE APPLICATION OF NEWLY PUBLISHED STANDARDS IS REQUIRED FOR ALL WORK UP TO THE 30% PROJECT DESIGN APPROVAL LEVEL. ALL DESIGN AND CONSTRUCTION WORK AFTER 30% PROJECT DESIGN APPROVAL MAY USE CONSTRUCTION STANDARDS THAT IMMEDIATELY PRECEDE THE NEWLY UPDATED STANDARD, UNLESS THE IMMEDIATE ADOPTION OF NEWLY PUBLISHED STANDARDS IS MANDATED.

USE OF "BLOCK STOCK" MUST BE COORDINATED WITH INVENTORY & LOGISTICS AND IS GENERALLY ONLY APPLIED AS A "LAST RESORT" AFTER CONSULTATION AND AGREEMENT WITH STAKEHOLDERS AND AN ALTERNATE SOLUTION, SUPPLIER, MATERIAL OR METHOD IS DEEMED ACCEPTABLE AND AVAILABLE.

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MANUAL	CONTACT	EMAIL ADDRESS	PHONE
Electric Distribution Design Manual	Fidel Castro	FRCastro@sdge.com	(858) 654-1607
Overhead Construction Standards	Mike Forchette	mforchette@sdge.com	(619) 244-7495
Service Standards & Guide	Jennifer Mann	jmann@sdge.com	(619) 676-1680
Electric Vehicle Supply Equipment Standards	Jennifer Mann	jmann@sdge.com	(619) 676-1680
Underground Construction Standards	Eddie Alcobia	ealcobia@sdge.com	(619) 574-4988
Electric Standard Practices	Joey Kucharyski	jkucharyski@sdge.com	(760) 566-5919
Tool Catalog	Roy Guilao	rguilao@sdge.com	(760) 672-6211

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SCOPE

This design standard establishes detailed protocols for tagging and retagging equipment across both new and existing distribution systems. It defines the conditions under which asset identifiers – such as Equipment IDs and Structure IDs – must be assigned or updated, particularly during feeder reassignments and cutover operations. The standard ensures consistent labeling practices that support accurate GIS mapping, safe field operations, and reliable system documentation.

DEFINITIONS

- Compatible Units (CU) – An SAP term used for Individual material, equipment and/or labor units used to design and construct a job within the SAP system.
- Equipment ID – A unique identifier assigned to each piece of equipment within the distribution system. The identifier is derived from the associated feeder ID.
- Feeder ID – A circuit identifier for each distribution circuit on the SDG&E's system. Assigned by Electric Distribution Planning.
    - Distribution 12 kV circuit – feeder ID is numeric
    - Distribution 4 kV circuit – feeder ID is alphabetical-numeric
- GIS – Geographic Information System, SDG&E's mapping system.
- Retagging – The process of updating Equipment IDs and Structure IDs on the distribution system, typically when the Feeder ID changes for Equipment IDs and structures are moved for Structure IDs.
- SAP – Systems, Applications and Products in Data Processing. Home to SDG&E's accounting & finance, logistics and as-builts.
- Structure ID – A unique identifier assigned to all electrical structures on the distribution system. It serves as a stable reference point across operational systems, ensuring traceability and consistency.
- Tagging – The process of identifying and tagging all new Equipment IDs and Structure IDs on the distribution system, typically for new construction.
- Transformer Loading Program (TLM) – Engineering initiative designed to monitor and manage the electrical load on distribution transformers to ensure safe, efficient, and reliable operation.
- TLM Change Form – A standardized form used to help Mapping & Records accurately identify which customers are connected to which transformers and circuits. It ensures correct service mapping, supports load analysis, and improves coordination between Planning, Design, and Field Operations.

CRITERIA

A. Most identifiable distribution equipment requires an Equipment ID, including:

1. Transformers
2. Cable
3. Capacitors
4. Overhead and Underground Switches
5. Reclosers/Service Restorers
6. Primary Meters
7. Regulators
8. Existing Grounding Banks

B. All distribution structures require a Structure ID, including:

1. Poles

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2. Manholes
3. Handholes
4. Transformer Vault Rooms
5. Pads

C. Tagging New Equipment

1. For newly introduced assets, input the actual Compatible Unit (CU) code corresponding to the equipment, or structure. This action activates the tag generation function associated with the CU within the iCUE system.
2. You may also use the T.A.G.S. method when unique IDs are required, such for Joint Poles or MVIs. These IDs should then be entered using the "Input Tag IDs Yourself?" option within the tag icon (see Figure 1) and clearly noted on both the one-line diagram and the sketch.

D. Re-tagging Equipment

1. Only retag a transformer or any Equipment ID when the Feeder ID changes. Typically, a Feeder ID changes when a load transfer or circuit cutover occurs.
   a. Accurate tagging is essential for safety and operational reliability. It prevents misidentification hazards, protects field crews, and ensures data integrity in GIS and SAP systems. This accuracy improves the customer experience by enabling timely and correct outage notifications, helping customers stay informed.
2. If a structure is moved by more than 20 feet or moved across the road/street, it will require a new Structure ID.
3. All 4kV to 12kV cutovers will require a new Equipment ID, but the Structure ID does not change.See DM6214.
4. The Distribution Project Management (DPM) Team developed a Retag Manual, which provides detailed examples and guidance. Refer to this manual as a resource for best practices and illustrative examples.
5. How to Re-tag Equipment and Structures
   a. Preferred - iCUE Method:
      1) Upon entering the specific retagging CUs use the iCUE Portal to obtain Structure ID and Equipment ID tags by selecting the following tag icon, Figure 1. See Retagging Underground CUs and Overhead CUs in NOTES.

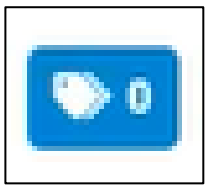


Figure 1

SAP Icon for TAG and RETAG in SAP

      1) To synchronize iCUE to SAP, use the "SAP-Sync" function.
   b. Alternate - T.A.G.S Method:
      1) Using the T.A.G.S. creation portal.
      2) Call out the new Equipment ID tags on the design sketch.
      3) Once the design sketch is pre-digitized and implemented into GIS, the Equipment ID will synchronize into SAP to avoid duplication.

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NOTES

i. A few retag Compatible Units available:

1. Underground System:
   a. Compatible Units (CUs) needed to retag PADMOUNT EQUIPMENT, **TAG-RE**
   b. Compatible Units (CUs) needed to retag SUBSURFACE EQUIPMENT & SWITCHES, **RE-TAG**
   c. Compatible Units (CUs) needed to retag CABLE on cable pole, **RT-CP**
   d. Compatible Units (CUs) needed to retag CABLE in existing handhole, **RT-HH**
   e. Compatible Units (CUs) needed to retag CABLE in existing manhole, **RT-MP**
   f. Compatible Units (CUs) needed to retag CABLE in existing manhole street, **RT-MS**
   g. Compatible Units (CUs) needed to retag PADMOUNT STATION, **STA-RT**
   h. Compatible Units (CUs) needed to retag CABLE in existing customer vault, **RT-CV**
2. Overhead System:
   a. Compatible Units (CUs) needed to retag OVERHEAD STATION, **RESTA**
   b. Compatible Units (CUs) needed to retag SCADA CAPACITOR, **RESTC**
   c. Compatible Units (CUs) needed to retag OVERHEAD SWITCH, **RETAG**
   d. Compatible Units (CUs) needed to retag POLE, **TAGRE**

REFERENCES

I. DPM Manuals & Guides - Retag Manual
II. Transformer Loading Management Change Form - TLM Change Form
III. iCUE, used by Designers or Planners to Generate Structure ID and Equipment ID Tags for New Equipment
IV. T.A.G.S. - used by Designers or Planners to Generate Equipment ID Tags for Existing Equipment
V. Electric Distribution Design Manual 6214, Expansion of the 4KV System
VI. Electric Distribution Design Manual 5625, Transformer Replacement Guideline
VII. Overhead Construction Standard 211, Distribution Structure Numbering
VIII. Overhead Construction Standard 213, GIS OH Map Symbol Table
IX. Underground Construction Standard 3111, Distribution Structure Numbering
X. Underground Construction Standard 3113, GIS UG Map Symbol Table

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A. CLIMBING SPACE

Climbing space is the space reserved along the surface of a climbable pole or structure (i.e., wood poles or smooth non-wood poles with steps) that permits ready access for linemen to equipment and conductors.

The location of the climbing space is measured from the centerline of the pole and shall be provided on one side or may be rotated in one quadrant in the area of an acknowledged obstruction of poles or structures. See O.H. Standards 251 for Company Standards. G.O. 95 states the minimum climbing space dimensions.

1. Armless Construction

Armless construction is construction without the use of crossarms. Other mechanical devices are used to support conductors and other components.

a. 12kV and Above

1) Tangent construction (G.O. 95, Rule 54.11 F. 1)
For a single circuit at the top of a pole, the climbing space shall be maintained to the lowest conductor on the climbing side of the pole. The climbing space shall be maintained through the conductor level (4 ft. above and below).

The climbing space shall be a square of the following horizontal dimensions:

0.75-46 kV	36 inches
46-75 kV	48 inches
More than 75 kV	48 inches plus ½ inch per kV over 75 kV

Fiberglass supports are considered to be crossarms when determining climbing space.

EXCEPTION: For a circuit at the top of the pole, the climbing space shall be maintained to the lowest conductor of the circuit on the climbing side of the pole. For a pole top circuit that includes buck position conductors located within a vertical distance of 4 feet or less from the lowest associated line conductor, climbing space need only be maintained to the lowest conductor in the buck position on the climbing side of the pole.

2) Deadend Construction (G.O. 95, Rule 54.11 F2, Fig. 54-11)

Climbing space through the levels of conductors dead-ended on poles in vertical configuration shall be a square, and one side shall be parallel and bounded by the vertical plane of the dead-ended conductors.

Dimensions:	0.75-7.5 kV	30 inches
	7.5-46 kV	36 inches
	More than 46 kV	36 inches plus ½ inch per kV over 46 kV

b. 4kV

The only difference in climbing space requirement between 4kV and 12kV is the size of the climbing space.

2. Line Arm Construction (G.O. 95, Rule 54.7A)

The climbing space shall be maintained in the same position for a distance of not less than 4 feet vertically above and below each conductor level through which it passes. Climbing space shall not be changed through conductor levels that are less than 4 feet apart. If the vertical distance between conductor levels is greater than 4 feet and less than 8 feet, the climbing space may be shifted not more than one-quarter of the distance around the pole.

Where a single level of circuitry is installed at the top of a pole, the climbing space shall extend up to the level of such pole-top circuitry and need not be provided through and above such level.

a. Line Arm Construction Dimensions (G.O. 95, Rule 54.7A1)

The climbing space where line arms are involved, without related buck arms, shall be on one side or on the face of the pole, with the center line of the pole approximately midway on one side of the climbing space.

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Dimensions:	0-7.5 kV	30 inches
	7.5-46 kV	36 inches
	More than 46kV	36 inches plus 1 /2 inch per kV over 46kV

3. Buck Arm Construction (G.0. 95, Rule 54.7A2)

   Buck arms are used when it is desired to change the direction of a circuit or extend a circuit in another direction. The addition of buck arms changes the climbing space requirements. See O.H. Standards 251. The climbing space where line arms and related buck arms are involved on poles or structures shall be on one side or face of the pole or in a quadrant as defined below:

   a. Where the vertical clearance between conductors on line and buck arms is 4 feet or more, the climbing space dimensions shown below shall be provided on one side or face of the pole for each arm.

Dimensions:	0-7.5 kV	30 inches
	7.5-46 kV	36 inches
	More than 46 kV	36 inches plus 1 /2 inch per kV over 46 kV

   b. Where the vertical clearance between conductors on line and buck arms is less than 4 feet, the climbing space shall be provided through such levels and located in a quadrant and shall have at least the following dimensions.

Dimensions:	0-7.5 kV	30 inches
	7.5-35 kV	42 inches

   3. For combination arm construction with line and buck arms:

      1) Where vertical separation between conductor levels on line and buck arms is 4 feet or more, the climbing space dimensions shown below shall be provided on one side or side or face of the pole for each level.

Dimensions:	0-7.5 kV	30 inches
	7.5-46 kV	36 inches
	More than 46 kV	36 inches plus 1 /2 inch per kV over 46 kV

      2) Where vertical separation between conductor levels on line and buck arms is less than 4 feet, such separation shall not be less than 2 feet, and the climbing space shall not be less than the dimensions shown below. The dimensions shall also be in accordance with the highest voltage adjacent to the climbing quadrant.

Dimensions:	0-7.5 kV	30 inches
	7.5-35 kV	42 inches

4. Allowable Climbing Space Obstructions (G.O. 95, Rule 54.7A3)

   See Rule 54.7A3 of G.O. 95 for these limitations.

5. Joint Poles (G.O. 95, Rule 93)

   Telco is to allow climbing space to gain access to facilities above them.

6. Clearance Poles (G.O. 95, Rule 54.8C2)

   A clearance pole is a pole that supports conductors for the purpose of obtaining/maintaining prescribed clearances. If supply service drop conductors are positioned at least 25 inches (horizontally) from the center line of the pole, service drops may be supported at a vertical distance of fewer than four feet but not less than 24 inches above a communication circuit.

7. Rack Construction (G.O. 95, Rule 54.9F)
   a. Standard Position - A climbing space shall be maintained 4 feet above the top conductor and four feet below the bottom conductor.
   b. Under Transformer - When the rack is mounted under a transformer, the climbing space is on the back side of the pole (See G.O. 95 Rule 54.7A).
   c. Reduced Clearances - When a clearance involving a secondary rack is reduced to four feet, there may be only one attachment.

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8. Transformer Through Bolts (G.O. 95, Rule 58.1 B3)

   Transformer through bolts that extend into the climbing space shall be covered with a suitable protective covering.

B. Working Space
   1. Working space is defined as the space reserved for working below, above, and between conductor levels.
   2. Working space dimensions shall be as defined in G.O. 95, Rule 54.7.

REFERENCES

a. OH Construction Standard 251, Working and Climbing Space
b. Original General Order 95, Rules For Overhead Electric Line Construction

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SCOPE

This design standard provides criteria to be considered when designing overhead pole lines to minimize the visual impact of the lines on the public.

CRITERIA

A. Line Simplification

1. The need for overhead lines to be inconspicuous and to blend into the surroundings can best be accomplished by:
   a. Avoiding unnecessary line duplication, such as placing poles on both sides of a street.
   b. Using joint construction with the CIP (Communication Infrastructure Provider). The design shall abide by the structural loading requirements of all supply and communication facilities planned to occupy the pole. The "planned" facilities are known to SDG&E at the time of design. This requirement applies to new poles and poles being replaced.
   c. Consolidating circuits wherever possible.
   d. Keeping pole heights as low as legal clearances will allow.
   e. Using only the required material and components needed to construct the pole/line safely and as requested in the design.
   f. Using cable secondaries and services.
   g. Omitting unnecessary guys.

B. Vertical Construction

1. Vertical construction is permitted for new construction only with an approved deviation request.

C. Maintaining Uniformity

1. Compatibility with other components of the line is an important principle to observe. This can be achieved in the following ways:
   a. Design a line having straight alignment wherever possible.
   b. Maintain the conductors at a grade even with the contour of the ground.
   c. Use current construction standards. However, when reworking a line, use the current construction standards, not those retained for FMO (Field Maintenance Only).
   d. When replacing insulators, ensure all insulators are the same type.

   NOTE: The neutral insulator can be a different color and/or size. See OH430, note I for further information.

D. Important Incidental Details

1. Attention to small details is also important to pole line aesthetics. The following details should be considered:
   a. Straightening poles, crossarms, and other equipment when required.
   b. Pulling excessive slack from conductors and guys (sags of all components in a span should be made in accordance with DM5911).
   c. Removing damaged weatherproof wire covering or replacing conductor when requested.
   d. Controlling excessive lengths of jumpers, drip loops, and other incidental wiring.

REFERENCES

I. None

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SCOPE

This design standard provides criteria for the design process associated with overhead to underground conversion projects.

CRITERIA

A. Conversion Considerations

1. The following questions are to be considered when designing an overhead conversion project:
   a. Is the proposed conversion boundary practical?
      1) Can improvements be made to better fit the overhead and/or underground requirements?
      2) Check for alternate circuit feed(s) and cutover or rearrangement opportunities to avoid converting more or less than necessary. This must be done at the time of the preliminary boundary check on 20A projects.
   b. Are there existing circuits in the conversion area and primary voltages available?
   c. What impacts could electrification have on the conversion area?
   d. Are there existing customers in the conversion area? What voltage and number of phases are required to serve the existing customers? What is the availability of the neutral? What power is required to serve the load? What are the size and type of loads to be served?
   e. Can the underground facilities be extended from existing ones in or adjacent to the conversion area?
   f. What are the locations of the required Cable Poles (CP)? Can the number of cable poles be reduced by rerouting or cutovers? What is the visual impact of the proposed cable poles?
   g. What are Electric Distribution Planning (EDP) and/or District Engineering requirements in relation to proposed cutovers within the proposed conversion area?
   h. Do not reroute the circuit to adjacent streets in order to avoid conversion.
   i. Are there key bifurcation points available to install fault indicators?
   j. What switching is required to make the conversion?
   k. What will be the fusing requirements?
   l. Are there existing capacitors in the conversion area that may be removed or relocated to a location outside of the conversion boundary? Are new capacitors required in the conversion area?
   m. Are there street improvements involved in the conversion?
   n. What are the rights-of-way required to complete the conversion?
   o. What are the CIP (Communication Infrastructure Provider) requirements?
   p. What permits are required from city, county, state, scenic highway, coastal zone, environmental or vegetation management?
   q. What is the visual impact of the entire job?
   r. Are there any construction constraints, such as the accessibility of heavy items (transformers, manholes, handholes) and other items requiring special installation equipment?

B. Cable Poles

1. The number of runs up any single cable pole should be limited to two runs and two spares (one spare for each circuit run). The backside of the ladder arm(s) is reserved for secondary and CIP attachment. Poles with switching equipment (e.g., MVR) should be evaluated case-by-case.
2. Risers should not be placed at the edge of the quadrant climbing space. Where practical, half-pole climbing space must be maintained.

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3. New cable poles shall have a standard setting depth of 9ft to prevent unearthing the pole during conduit installation. It is unnecessary to reset an existing pole converted to a cable pole.
4. All riser quadrants shall be field coordinated with the CIP's engineer/designer whose name is shown on the work order for joint cable poles and cable pole replacements. CIPs shall be given quadrant locations in writing and on job sketches.

REFERENCES

I. Overhead Construction Standards 303, Pole Information

II. Overhead Construction Standard 1402 and Underground Construction Standard 4202, Standard Joint Cable Pole Riser Positions

III. Service Planning Manual 705, Conversion Procedure – Rule 20.A

IV. Service Planning Manual 228, Joint Pole Facilities

V. Overhead Construction Standard 1451, 12.47 kV and Below Deadend Cable Poles

VI. Underground Construction Standards 4344-4360, Fault Indicators

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SCOPE

This design standard provides common General Order 95 (G.O. 95) infractions identified while fielding overhead jobs, along with suggestions to correct these infractions.

CRITERIA

A. Common Infractions with SDG&E Equipment

1. The following is a list of common overhead infractions found when fielding a job:
   a. PVC riser in climbing space.
   b. Exposed secondary in climbing space (e.g. rack, aerial cable).
   c. Cutout or pothead in climbing space.
   d. Service drops in climbing space.
   e. No climbing space at
      1) 12 kV
      2) 4 kV
      3) Secondary level.
   f. 12 kV jumper or cable in climbing space.
   g. More than two guy wires within a 4ft section of climbing space.
   h. Insufficient clearance between conductor levels.
   i. Lack of coordination between overhead and underground jobs regarding what quadrant to utilize for UG risers.
   j. Loose guy wire.
2. Correction of infractions should be included as part of the job being prepared. Other considerations in fielding and designing overhead jobs are:
   a. When designing overhead construction not depicted in the Overhead Standards, a deviation request should be submitted to Electric Distribution Engineering (EDE) for review.
   b. Illustrate complicated corner poles to show climbing and working space.
   c. Arrange arms, conductors, and equipment on poles so the climbing space is not rotated more than once. If possible, arrange for climbing space consistent with CIPs.
   d. Infractions caused by CIPs – Follow Compliance Management Notification of G.O. 95 Rule 18 Infraction process.

B. Common Infractions with CIP Equipment

1. Less than 6ft below SDG&E primary conductors.
2. Less than 1ft below or 2ft above a street light bracket.
3. Not properly dead-ended when changing from tensioned construction to slack construction (three bolt clamps on the side of the pole is not acceptable).
4. Obstructing the climbing space on a pole.
5. Less than 6ft of clearance without a guard arm on a clearance pole across a street when more than one power service is on the pole.
6. Insufficient clearances at mid-span and/or at the pole.
7. Guard arms that are not properly oriented.
8. Loose lashing wire.

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REFERENCES

I. General Order 95 Rule 18, Maintenance Program and Resolution of Potential Violations of General Order 95 and Safety Hazards

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SCOPE

This design standard lays out typical design requirements for work requiring a Right of Way permit in the City of San Diego. Please note, additional design requirements beyond the items listed below may be needed to obtain a Right-of-Way permit from the City of San Diego.

DEFINITIONS

- Right of Way (ROW) - shall mean the publicly dedicated right-of-way of the CITY, which are public easements for streets, alleys, or other uses, as defined in San Diego Municipal Code section 113.0103, as may be amended from time to time.
- Excavation - shall mean the act, process, or result of earthen material or substance being removed, cut into, dug, quarried, uncovered, displaced, or relocated.

CRITERIA

The following should be considered when preparing a design for excavation in the City of San Diego's Right of Way.

A. Design Requirements

1. Vicinity map (no aerials)
   a. Street names should be clear.
   b. The job site should be identified with a call out.
2. Identify facility ID numbers.
3. North Arrow
4. Fully dimensioned set of plans, including font and scale requirements.
5. Identify address numbers of properties adjacent to work.
6. Identify legal description of the property (i.e., lot number, block number, subdivision name, map number and assessor's parcel number) and property Owner's name if project is for a specific property.
7. Identify street names.
8. Show and call out all **existing site conditions**. Dimensions and separations may be required to be called out. Including, but not limited to:
   a. Utilize City civil symbols.
   b. Identify curb and gutter location.
   c. Identify curb-to-property line distance.
   d. Dimension existing and proposed sidewalk (if any).
   e. Dimension front and side property lines.
   f. Location and width of the existing proposed driveway(s).
   g. Location of Existing utilities (show the type, size, and separation).
   h. Identify existing landscape/non-standard improvements in the parkway (if any).
   i. Identify the ROW width (R/W to R/W).
   j. Identify designated bike lanes.
   k. Identify driveways, utility boxes, fire hydrants, trees, curb ramps, street signs, any other existing private requirements.
9. Show and call out **proposed work**. Dimensions and separations may be required to be called out. Including, but not limited to:
   a. If retaining wall is proposed, detail of retaining wall is required.

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b. For poles, identify distance from existing to proposed pole, proposed pole to property line and face of curb, proposed pole to any nearby driveway flare, proposed pole to any trees, edge of pole to edge of sidewalk (if any) to determine walkway clearance.

1) 18in to be maintained from face of curb to edge of pole.

c. If the existing poles have guy wires & anchors or a streetlight attached, call out if it is to be transferred to the new pole or removed.

d. For pipes, identify size and length of proposed trenching, any RFS, and specify if it to be abandoned in place or removed from ground.

e. If concrete panels are being disturbed, show concrete joint lines for applicable panels.

B. Horizontal Separation Requirements

NOTE: Horizontal separations are to be measure from edge to edge. For example, from the edge of SDG&E utility to edge of other utility/structure (e.g., edge of gas pipe to edge of water pipe, edge of pole to edge of driveway flare). If minimum separation cannot be met, an approval from governing jurisdictions, agencies and disciplines will be required. This could include Water and Sewer (PUD), Landscape, etc. This may lengthen the review process.

1. Show and call out the required clearances from existing improvements to new underground structures. Minimum required separation for **underground** structures:

a. 10ft preferred; 5ft may be accepted to Sewer Mains (wet utilities)

b. 10ft preferred; 7ft may be accepted to Sewer Manhole

c. 10ft to Recycled Mains

d. 5ft to Water Mains

e. 5ft to Storm Drains

f. 5ft to Storm Drain Structures (i.e., curb inlets and cleanouts)

g. 5ft to all valves

h. 5ft from existing street tree

i. 1ft to other telecom and gas utilities

j. 3ft from face of curb (preferred)

k. 3ft to sewer lateral (service)

l. 5ft to water service

2. Show and call out the required separation distances from any existing improvements to new above grade structures. Minimum required separation for **above grade** structures:

a. 4ft walkway clearance per ADA requirements (If the 4ft minimum clearance cannot be met add sidewalk pop out to accommodate the 4ft clearance.)

b. 3ft to driveway flare (edge of structure to edge)

c. 10ft preferred; 5ft may be accepted to Sewer Mains (wet utilities)

d. 10ft preferred; 7ft may be accepted to Sewer Manhole

e. 10ft to Recycled Mains

f. 5ft to Water Mains

g. 5ft to Storm Drains

h. 5ft to Storm Drain Structures (i.e., curb inlets and cleanouts)

i. 5ft to all valves

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j. 10ft from an existing street tree

k. 1ft to other telecom and gas utilities

l. 3ft to sewer lateral (service)

m. 5ft to water service

C. Common Notes

1. Add a disclaimer for notes that give direction to contractors, not for permit:

   a. SPECIAL NOTES: THE FOLLOWING NOTES ARE PROVIDED TO GIVE DIRECTION TO THE CONTRACTOR BY THE ENGINEER OF WORK. THE CITY ENGINEER'S SIGNATURE ON THESE PLANS DOES NOT CONSTITUTE APPROVAL OF ANY OF THESE NOTES AND THE CITY WILL NOT BE RESPONSIBLE FOR THEIR ENFORCEMENT.

2. Add note when a driveway is being disturbed, add to the notes section:

   a. FOR WORK BEING PROPOSED IN A DRIVEWAY, ALL CONCRETE PANELS BEING DISTURBED SHALL BE REMOVED AND REPLACED FROM JOINT TO JOINT AND RESTORED TO THE ORIGINAL CONDITION. IN CASE THE ADJACENT CONCRETE PANELS ARE BROKEN/DAMAGED/LIFTED THAT CAN CAUSE A TRIPPING HAZARD, THEN THE CONTRACTOR SHALL EXTEND THE RESTORATION TO INCLUDE THE BROKEN/DAMAGED/LIFTED PANELS, TO THE NEAREST JOINT.

3. If any work is near entrance to private property (driveway or private walkway), add note:

   a. BEFORE STARTING ANY WORK OR CONSTRUCTION ACTIVITIES THAT WOULD INTERFERE WITH PRIVATE PROPERTY, PLEASE COORDINATE WITH PROPERTY OWNERS PER SECTION 10-D OF THE CITY OF SAN DIEGO'S MOU WITH SDG&E.

4. If any work is shown inside private property, add note:

   a. WORK ON PRIVATE PROPERTY FOR REFERENCE ONLY AND NOT PART OF PERMIT.

5. If impacting concrete panels, add restoration note:

   a. CONCRETE PANELS BEING DISTURBED SHALL BE REMOVED AND REPLACED FROM JOINT-TO-JOINT PER CITY STANDARDS.

6. If potentially proposing boring in-lieu of open trench, add note:

   a. BORING IN-LIEU OF OPEN TRENCH MAY BE A PREFERRED CONSTRUCTION OPTION DURING CONSTRUCTION. BORING WILL NOT PROPOSE ANY ADDITIONAL SCOPE OF WORK AND WILL NOT ALTER THE TRENCH LINE ALIGNMENT AND ELEVATION.

REFERENCES

I. City of San Diego Administrative Memorandum of Understanding with SDG&E Regarding Gas and Electric Franchise Agreements

II. San Diego Municipal Code Chapter 14, Article 2, Division 4

III. San Diego Municipal Code Chapter 11, Article 3, Division 1

IV. City of San Diego Sewer Design Guide 2015

V. City of San Diego Water Facility Design Guidelines 2021

VI. City of San Diego Street Design Manual 2017

VII. City of San Diego Information Bulletin 165

VIII. City of San Diego CADD Standards and Drafting Files

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SCOPE

This design standard provides criteria for the proper placement of new or existing distribution poles.

ATTENTION

A. Pole placements and designs shall be performed with the use of SDG&E-approved software and meet requirements for worker and public safety, pole and equipment accessibility, existing and future structures and utilities, and regulatory compliance.

B. The design shall consider the structural loading, as well as clearance and space requirements of all supply and communication facilities, including support structures planned to occupy the pole. The design shall also consider constructability and feasibility to transfer attached facilities from the existing pole to the new pole. The "planned" facilities are those that are actually known to SDG&E at the time of design. This requirement applies to all pole installations.

CRITERIA

The following general criteria should be considered each time a pole location is selected:

A. General Pole Line Access and Constructability

1. The pole should be located to minimize visual impact on the public.
2. Although a 5ft taller pole is commonly installed when replacing poles, a shorter or same size pole may be used to facilitate construction and operation as long as required clearances are met.
3. Present or future improvements should not be impacted by pole location.
4. Ensure poles are properly placed to prevent poles from being located on both sides of the street.
5. Avoid placing poles in locations without access, such as back lot lines, fenced-in backyards, etc.
6. Do not place sectionalizing or protection equipment (switches, fuses, and service restorers) on 'non-truck' accessible poles. This also applies to capacitors, regulators, and cable poles.
7. Poles shall be set such that all fused cut-outs are not installed higher than 40ft without an EDE-approved deviation request.
8. Poles shall be set such that all vertical sectionalizing disconnect switches are not installed higher than 50ft without an EDE-approved deviation request.
9. Avoid locating the pole where an angle with incoming conductors will cause excessive side pull.
10. Try to locate the pole so that normal crossarm construction can be used. Alley arm construction should be avoided.
11. Avoid locating a pole near trees, fire hydrants, signs, water lines, sewer, CIP (Communication Infrastructure Provider), and buildings that would block digging or climbing access to the pole.
12. Allow space for overhead and underground CIP attachments in accordance with SDG&E attachment policy.
13. It is preferred to set new pole on property line.
14. Poles should be located behind the sidewalk. In situations where this is impossible, poles may be placed in the normal sidewalk provided the sidewalk is widened to provide a minimum of 4ft of useable walkway.

B. Cable Poles

1. If there is an existing feeder down a perimeter street that is included within the boundary of the subdivision and conversion of these poles is not required, any suitable pole may be used as a cable pole to feed the subdivision.
2. More than one cable pole may be established to provide service to a subdivision or development provided the additional service point(s) will:
   a. Result in an overall saving of construction costs to SDG&E on the project.
   b. Not adversely affect system integrity and reliability.

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c. Not adversely affect the aesthetics of the project's future inhabitants and the neighbors surrounding the project.

d. Not require the introduction of new poles into our system. Project Management Supervisor may waive this condition if warranted by unusual conditions.

NOTE: If the developer can meet all the above requirements except B.2.a., the developer will be permitted to pay the additional costs of establishing more than one cable pole for the project.

3. Avoid designating a corner pole as a cable pole.

4. New primary cable pole installations shall be truck accessible. Existing pole locations that are not truck accessible can be "grandfathered" by approved deviation.

C. Pole Location in Conversion Areas

1. The nearest pole suitable for becoming a cable pole should be designated to serve the underground area if the nearest existing pole is not suitable. The cost of a new pole or relocating equipment on the existing pole should be weighed against installing additional cable to bypass the closest pole in lieu of another existing pole.

2. Some municipalities require the conversion of overhead facilities within one-half block of a new underground subdivision that may alter the location of the cable pole.

D. State Highways, Freeways, and Street Improvements

1. Replacing an existing pole adjacent to a designated scenic highway is allowed if the pole is replaced less than 4ft from the existing pole location. A move of 4ft or more is not considered by the CPUC to be in the same location and therefore requires either an exception from the CPUC or undergrounding of the line affected.

2. Avoid pole installation along the outside of a curve, especially on narrow secondary highways.

3. Future overhead facilities on secondary highways must be 20ft from the edge of the driven way. The edge of the driven way is defined as the white line on the side of the road.

4. Poles must be placed at least 30ft from the edge of the driven way on major highways and freeways. Overhead freeway crossings should be made in a single span, avoiding the placement of poles within the right-of-way limits.

5. No longitudinal encroachments should be planned for major highways or freeways. No encroachments should be planned within designated freeways and highways, with more than one lane each way. If in doubt, contact Land Management.

6. If a pole or structure is on a sidewalk, determine if moving the pole can be avoided by pouring an additional sidewalk. **Contact Land Management** for assistance.

7. The pole should be located away from existing intersections, corners, and driveways to reduce the risk of vehicle contact.

8. A pole that has been hit by a vehicle should have its location reviewed and analyzed by the appropriate C&O center to determine if relocating it would be feasible and would lessen the possibility of it being hit in the future.

9. In 15ft or 20ft alleys, pole positions should be 4ft or less from the property line to the face of the pole and as far off the edge of the roadway as possible within the public right-of-way.

10. In streets, a minimum clearance of 18in is required for new poles between the curb face or shoulder edge (traveled way) and the face of the pole. If street improvements do not allow for defined clearance, or if existing circuit or replacing existing pole, a deviation may be considered instead of a pole relocation.

11. On conventional highways, frontage roads, city streets, and county roads within the State right of way (all without curbs), the minimum horizontal clearance shall be the standard shoulder width as listed in Tables 302.1 and 307.2, except that a minimum clearance of 4ft shall be provided where the standard shoulder width is less than 4ft. Refer to Highway Design Manual (HDM) for latest information.

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E. Pole Locations Near Gas Lines

1. Power poles and/or anchors shall not be located closer than 5ft to any gas pipeline operated at more than 60 psi. Whenever it becomes necessary to locate a pole or an anchor in an existing pipeline right-of-way, every reasonable effort should be made to place the facility on the narrow side of the right-of-way to minimize the difficulty of installing a future pipeline.
2. Should it become necessary to locate the facility closer than 5ft from the gas pipeline, special precautions should be taken to:
   a. Positively determine the location of the pipeline with respect to the desired location for the pole or anchor by means of excavation in the field prior to any pole hole digging.
   b. Consult the **Gas Engineering Department** to determine if special construction is required. Should it be necessary to locate the pole or anchor nearer than 5ft from the pipeline, insulating or casing material may be installed to prevent accelerated fatigue at a welded joint or branch connection.
   c. Provide a permanent pipeline marker at the site to guide the line crews in the event of future repairs or replacements of either the pole or the anchor.

F. Transmission Pole Considerations

1. For all distribution spans within the scope that impacts transmission (i.e., 'Z') poles, a Request to Attach (R2A) is required. The designer or planner is responsible for submitting all R2As and including approved R2As within the 60% design deliverables. The typical turnaround duration of an R2A is 4-6 weeks. If you need additional information/access, please submit a Construction Standards Request to the Electric Distribution Engineering Dashboard.
2. The following includes typical scenarios that require R2A analysis:
   a. Modification of distribution lines that pass or cross under transmission lines.
   b. Modification of distribution lines that are adjacent to transmission lines (if distribution pole heights are increasing, blowout of transmission line needs to be considered).
   c. Modification of distribution lines that attach to transmission poles.
   d. Addition of physical load to an existing transmission structure.
   e. Pending Pole Calculation R2A Requests:
      1) Designer shall monitor status of pending approval request and periodically update design documents and the design team as needed.
   f. Approved Pole Calculation R2A Requests:
      1) Designer shall update design and construction documents and update the project management team as needed.
   g. Review and approval by EDE may be necessary to ensure worker safety and climbing space are maintained.

G. Substation Pole Considerations

1. Substation design should be consulted for exact pole placement if a pole needs to be installed within 20ft of a substation fence.
2. Obtain site plans for current and future substation getaways.
3. Obtain site plans for current and future access roads, utilities, and buildings.

H. Replacement Structure and Anchor Staking/Location Considerations

1. The available types of structure and anchor replacements for a given location can vary based on numerous factors (i.e., accessibility, obstructions, topography, land rights, etc.). Below are terminology definitions and subsequent implications for considerations during job walks.

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a. Set Tight (preferred) – Pole set location within a 2ft proximity (existing pole face to proposed pole face) to an existing pole. In general, 'set tight' implies the new location is within existing land rights.

b. Same-Hole Sets – Pole set location in the same exact location as the existing pole.

c. Truck Set – Pole set location that is bucket/line truck accessible and has no environmental, biological, cultural, or other constraints preventing a bucket/line truck from traveling to the subject location.

d. Helo Set - Typically used when there is no apparent access for any construction vehicles to the pole location or within environmentally/biologically/culturally sensitive areas.

e. Backyard Machine Set – Typically used when the pole is not bucket/line truck accessible, the smaller backyard machine can be used to set the pole.

f. Crane Set – Typically used when a pole is too far away for a typical bucket/line truck to set the pole but not so remote as to need a helicopter.

g. Anchor Lead Length – Anchor set location from the outer pole surface at a specified length.

h. Impacted Structures – Adjacent existing conductor span(s)/structure(s) that are impacted (typically, the pole and span directly adjacent to a replaced pole) but not identified for replacement. Any impacted structure(s) be sufficiently modeled and analyzed for compliance.

REFERENCES:

I. Service Standards & Guide SG 204, Customer-Owned Service & Meter Poles Permanent/ Climbable 0 – 600 Volts

II. Service Standards & Guide SG 205, Customer-Owned Service & Meter Poles Temporary/Non-climbable 0 – 600 Volts

III. Overhead Construction Standards 200, Practices

IV. Overhead Construction Standards 300, Poles, Arms & Hardware

V. Electric Distribution Engineering Dashboard: EDE Request Dashboard - PowerApps

VI. Caltrans Highway Design Manual (HDM)

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SCOPE

This standard provides considerations for the selection of poles based on mechanical requirements, overhead construction techniques, geographical location, and known local conditions.

APPLICATION

A. The following considerations must be included in the proper selection of a pole:

1. Poles shall be of adequate length to provide at least the minimum conductor clearances above ground and from other utility's conductors, including Communication Infrastructure Providers (CIPs) and other structures per G.O. 95 (See Overhead Construction Standards 220-224).
2. For a new pole being set, or a pole replacement, where the pole is bucket truck accessible, design into and maintain sufficient clearance to accommodate the use of a bucket truck and rubber gloving work method. Sufficient clearance will be a minimum of six feet between two primary levels, primary and secondary level, primary line and buck, or primary and communication level.
3. It is recommended that a five-foot taller pole be installed for pole replacements.
4. A pole loading calculation analysis is required to determine if pole classes are adequate for all vertical and horizontal loadings by using approved software. The design shall consider the structural loading requirements of all supply and communication facilities planned to occupy the pole, and must be calculated using approved software. The "planned" facilities are those that are actually known to SDG&E at the time of design. This requirement applies to new poles and poles being replaced. A post-construction pole load calculation must be performed for all poles upon completion of construction. This post-construction "true-up" report shall include all pole loads, applicable load cases and shall state "percent remaining strength" used for the calculation and the date such intrusive data was obtained. This post-construction report shall be placed in PIDS (Pole Information Data System) within 10 months after completion of construction.

   NOTE: For steel pole construction, the design shall take into consideration the factory drilled hole locations to reduce the amount of field drilling required during construction. The factory drilled hole locations ("knockouts") shall be used for calculation purposes in the design when determining attachment heights on the pole for crossarms, equipment and guying. Refer to Overhead Construction Standard 310 for steel pole factory drilled hole pattern.
5. Poles must be designed to meet the loading conditions as set forth in Electric Transmission & Distribution Engineering Standard 12100 "Direct Buried Pole Selection and Loading Criteria" in accordance with Non-Operational Electric Standard Practice (ESP) 015 "Structural Pole Loading Calculation Requirements." Additionally, poles in High Fire Threat Districts Tier-2 and Tier-3 must be designed in accordance with Overhead Construction Standard page 340.2, section 2. In all cases, facilities will meet or exceed G.O. 95. Refer to Table 1.
6. Determine if any special hauling and/or digging instructions are required.
7. Determine adequate guying for the design.
8. Determine pole stepping requirements. See Overhead Construction Standard 363.
9. Determine future pole height requirements. Consider future distribution, possible joint utility attachment(s).
10. Minimum pole class shall be class 1. See Overhead Construction Standard 354 for pole classes.
11. Provide room for pole-bolted transformers when they are needed. This can be done using either (a) taller poles for rearrangement of conductor levels, or (b) pole top extensions (see Overhead Construction Standard 473). Wood pole top extensions are not to be used on steel poles.
12. The preferred construction in the Cleveland National Forest (CNF) shall be weathering steel poles. Composite poles are available for use in wetland areas of the CNF.
13. Weathering steel poles are not to be installed in Contamination District 1. Refer to Table 1
14. Steel poles shall not be used in wetland/high water table areas. In these cases, composite poles shall be used. Refer to Table 1.

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15. Weathering steel poles are not to be installed in sidewalks (improved streets), as they will stain the sidewalk when the patina is washed off the pole due to rain or irrigation. Refer to Table 1.

16. All steel poles shall be grounded as described in OH Standard 1000.

B. Pole Selection Matrix

1. TABLE 1 will help to identify what type of pole to use in certain locations. As always, field conditions should be considered when choosing the correct pole. Aesthetics should be considered in some cases.

TABLE 1

Application Location	Wood	Galvanized Steel	Weathering Steel	Composite
Back Lot	✓	✓	✓	✓
Cleveland National Forest	-	-	✓	**
Contamination District 1	✓	✓	-	✓
Contamination District 2 & 3	✓	✓	✓	✓
High Fire Threat Districts Tier-2 and Tier-3	-	✓	✓	**
Improved Street	✓	✓	-	-
Unimproved Street	✓	✓	✓	*
Wetland	*	-	-	✓
High Wind (Circuit-170, 171, 172, 221)	-	-	✓	-

✓ = Approved

- = Not Approved

* = Approved by Deviation request only

** = Approved for use in wetland area of CNF and the High Fire Threat Districts Tier-2 and Tier 3.

C. Custom Embedment

1. See OH303 for the use cases and additional considerations of custom embedment.

2. The custom embedment approach requires project-specific engineering based on site conditions, loading, and performance requirements. Under this approach, the Engineer of Record (EOR) selects appropriate analysis methods, which may include, but are not limited to:

   a. **MFAD analysis** per the latest TG-0010, applicable to both direct-buried poles and poles supported by pier foundations. This method is preferred when pole deflection is a critical consideration.

   b. **Fleming analysis**, applicable only to direct-buried poles.

   c. **Broms analysis**, applicable only to direct-buried poles.

   d. **Micropile foundations**, when site conditions warrant their use.

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NOTES:

A. Steel poles come pre-drilled from the factory with knock-out holes. If field drilling holes consistently in the same location, contact Electric Distribution Engineering for possible additional knock-outs. See Overhead Construction Standard 310 for factory drilled hole locations ("knockouts").

B. Pole Loading Calculation Compliance Training is MANDATORY before performing pole loading calculations.

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SCOPE

This design standard provides criteria for the design and construction of crossarms on the overhead electric distribution system.

CRITERIA

A. Crossarm Construction Standards – The SDG&E Electric Distribution Design Manual and Overhead Construction Standards are the primary source of information for crossarm design, application, and construction. Distribution crossarms may be comprised of wood, composite, or steel material and arranged as tangent, dead-end, alley, or "buck" configurations. Steel davit arms may also be used to support distribution conductors that are under-built on transmission structures. Allowable loading values for all crossarms are tabulated in Construction Standards (see references). Standard tables show the allowable loading values for vertical, horizontal, and transverse crossarm loads, including crossarm length, cross-section dimensions, weights, bolt-hole, and pin hole diameters and locations, stock numbers and design units. Additional Construction Standards for connector hardware, pins, insulators, conductors, guys and poles are listed in the references section.

Crossarm Structures and Loads - Conductor loads are transferred to the crossarm via pin and insulator connections. Crossarms are designed to support conductor static bearing loads and variable dynamic loads such as ice, wind, differential tension, and angle loads. Wood crossarms are attached to the pole by a single thru-bolt and a steel brace. Composite crossarms are attached to the pole via a 2-bolt metal bracket. Crossarms may be installed on wood, steel, concrete, or composite distribution or transmission poles.

Crossarm Modeling and Analysis Software – Due to the complexity of calculating crossarm loads, only PLS-CADD or O-Calc software tools are approved for use to analyze crossarm loading capacities and structural performance to ensure a high degree of public safety and regulatory compliance. Associated analytical support resources such as LiDAR data, Civil/Structural Engineering support, manufacturer data and use of the SDG&E Crossarm Check MASTER is also available. Any deviation from published Construction Standards must be approved by EDE before construction.

APPLICATION RECOMMENDATIONS

A. General Considerations

1. Compliance with published Construction Standards is required unless a deviation from such standards is approved by EDE.
2. New crossarms shall be installed unless existing crossarms are deemed acceptable and in good working condition by a QEW supervisor or structural engineer. Existing crossarms should be replaced if there is any irreparable evidence of splitting, rotting, tracking, damage, or deterioration.
3. Standard crossarm configurations shall be used unless a deviation request has been approved by EDE.
4. Composite arms shall be used in the HFTD.

B. Crossarm Properties

1. Crossarms are selected based on their structural capacity to support applicable design loads. Crossarm loading analysis is intended to analyze expected static and dynamic mechanical conductor loads based on conductor type and size, crossarm arrangement and mandatory loading conditions. Composite crossarm loading values can be found in OH379. See references for other relevant Overhead Construction Standards.
2. If applicable loads exceed crossarm strength guying and stub pole structural support should be considered.
3. Both O-CALC Pro and PLS-CADD are approved software programs. Either must be used to analyze crossarm loads and crossarm selection.

   NOTE: When PLS-CADD is used, crossarm loading should be analyzed based on a minimum L2 analysis and should match the analysis level used for the rest of the structural analysis within PLS-CADD.

C. Crossarm Pin & Pin Spacing

1. A critical characteristic of fire risk mitigation on a **bare conductor** is providing sufficient pin spacing. Pin spacing is defined by regulatory codes and SDG&E Standards. **Minimum** required pin spacing is dependent on the following factors:

   a. Number of wires on the crossarm

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b. Conductor sag

c. Span length

d. Take off angle

e. Conductor voltage

f. Load Case

g. Pin spacing shall be determined by the SDG&E Crossarm Check MASTER.

2. Pole top compatibility with adjacent structures shall be analyzed to ensure compliance with all clearance and loading value requirements.

3. New poles and anchors shall be designed to accommodate a 4th wire.

4. The preferred crossarm length for single circuit shall be 10ft. If exceptions exceed 12ft maximum length, an approved standard deviation is required.

D. Pins

1. The following pins shall be used as described in OH396.

   a. 1-3/8in straight pin

   b. 1-3/8in angle pin

   c. 1in pole top pin

2. Pin Spacing

   a. At a minimum, for a bare conductor, pin spacing shall be checked in the "SDG&E Crossarm Check MASTER" file, in which the crossarms are analyzed.

   b. Minimum pin spacing requirements must be met for all structures. Where pin spacing is insufficient, a Deviation Request shall be submitted for review and approval of alternative designs by EDE.

   c. Horizontal clearance (pin spacing) for distribution conductors shall be calculated based on the condition producing the maximum sag and is not to be less than 17-1/2in in accordance with G.O. 95. Covered conductor should also not be less than 17-1/2in. Maximum sag for pin spacing calculations is often derived from the Maximum Operating Temperature (MOT, 167° F) under the higher sag value from Final after Creep or Final after Load.

      NOTE: The method used for analysis should be identified to facilitate QA/QC efforts.

E. Alley Arms

1. Alley arms are installed:

   a. To avoid conductor contact with trees.

   b. To comply with easement and private property requirements.

   c. For street improvements that require the relocation of one or more poles to maintain existing conductor alignment.

   d. To maintain radial clearance from buildings through alleyways.

   e. To maintain a straight line in two directions on a corner with a wide radius.

F. Re-Building Existing Structures

1. To facilitate maintenance and construction of buck arm structures, all attempts shall be made to frame crossarms at 90° angles between line and buck levels.

2. The required vertical separation between the conductor on top and bottom (or line and buck) arms is 6ft, per OH303, Pole Information, unless a deviation request has been approved by EDE.

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3. For Line and buck configurations with delta configuration, crossarm separation needs to be 6-1/2ft to allow space for center phase attachment.
4. All efforts shall be made to modify pole top configurations prior to recommending composite phase spacers per OH755, Composite Conductor Spacer.
5. To stay conservative with respect to clearances, all crossarm framing may utilize 12in from T.O.P. (top of pole) for the top crossarm bolt.
6. Delta construction is acceptable for 3-wire primary:
   a. G.O. 95 climbing space requirements must be met for 3-wire delta construction buck spans.
7. For all terminal deadends (i.e., conductors only attached to one side and typically backed up by a guy, including stringing site deadends) with full tension and 336 ACSR or larger diameter, install double arms.
8. For all deadend configurations when utilizing wood arms, install double arms.
9. For Line & Buck Construction, the line arm (source) on top is preferred.
10. Existing arms to remain can maintain their current attachment height unless they need to be moved to convert to delta or for clearance reasons.
11. Different conductor phases should not be placed back-to-back on the same level deadend crossarm(s). Therefore, phasing fixes for transposition removals should be done on line and buck poles.

G. For 4kV Circuits:

1. All 4kV circuit conversion to 12kV should be based on 12kV standards.
2. All new construction on a 4kV circuit should be based on 12kV standards.
3. For crossarm sizing when utilizing a covered conductor, refer to OH2004.1. Adjustments should be made to keep existing easements up to 10ft.

H. Using Delta vs. Flat Configuration for Equipment Poles

1. Having a balanced crossarm is preferred. The following table shows when delta or flat crossarm configuration should be installed based on the pole type and equipment. If this is not feasible, a Deviation Request or Request for Information should be submitted to EDE Construction Standards for resolution.

TABLE 1

Delta Configuration – 3 Wire	Flat Configuration – 3 Wire
Terminal deadend pole If flat configuration will require an easement One transformer Radios Repeaters No equipment	Recloser/Switch Transformer Banks Capacitor Banks Line Monitors Primary riser with three cutouts Three in-line cutouts

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I. Single to Two-Level Transitions

1. When transitioning from a single level to two levels, utilizing the inner pin positions (24in from center on 10ft arm and 30in from center on 8ft arm) for the wires that come from the inside pin positions on the single level arm is preferred. This can be done on either the top or bottom arm of the two-level build (top shown on the attached sketch). See the Figure 1 below.

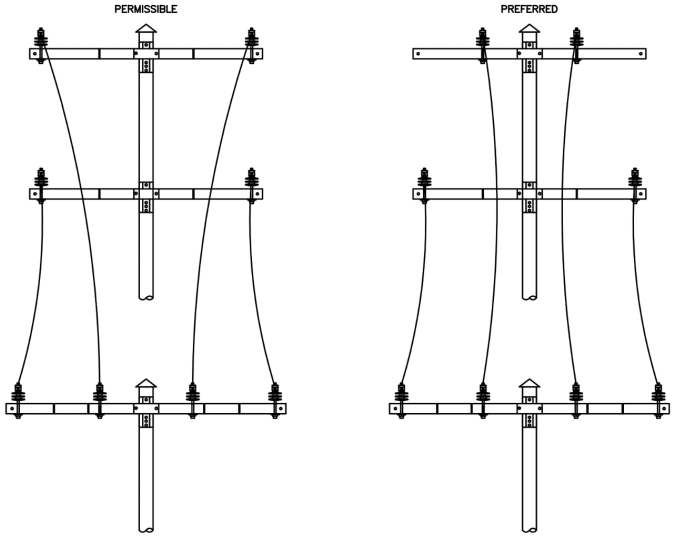


Figure 1

J. Permissible and Preferred Two-Level Pole Build

1. Going to all outside positions on a two-level build is still permissible, just not preferred.
2. The preferred position for the neutral is always on the bottom level. The planner should obtain concurrence from the district engineer on any proposed conductor re-arrangement BEFORE the job is sent to construction. Two-level construction that has three-phase equipment or a three-phase buck arm below will need a standard deviation submitted for each location. These deviations cannot be obtained for two levels utilizing 6ft arms. Maximum pole height for two-level construction is 70ft. An easement should be pursued if going two levels requires a taller pole. A two-level-to-two-level line and buck (4 primary line arms total) should be avoided.
3. When utilizing a two-level configuration for a single circuit on a pole, the arms may be referred to as TOP1 and TOP2 in all the applicable design and construction documents. Likewise, bottom arms that utilize a two-level configuration shall be referred to as BOT1 and BOT2.

K. Uplift

1. Uplift on tangent structures shall be calculated based on the PLS-CADD model. The uplift limit for different tie types can be found in OH760 and OH2010. It is preferable to avoid designing uplift on tangent poles.
2. Hand ties are not to be installed on new aluminum conductor.

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REFERENCES

I. Crossarms Shall be Installed and Analyzed per SDG&E – ETE&D, Technical Specification TE-0002 – PLS-CADD Specification - Section 5.3.8 Crossarms

II. Fiberglass, Steel and Wood Crossarm Design Spreadsheet Procedure for Use in SDG&E Projects, Rev. 1.8.1

III. O-Calc Pro Software

IV. Overhead Construction Standard 379, Composite Crossarms

V. Overhead Construction Standard 380, Wood Crossarms

VI. Overhead Construction Standard 381, Conductor Design – Vertical Loading

VII. Overhead Construction Standard 382, Maximum Conductor Loading on Crossarms – Vertical Loading

VIII. Overhead Construction Standard 383, Maximum Conductor Loading on Crossarms – Horizontal Loading

IX. Overhead Construction Standard 384, Double and Triple Crossarms with Double Arming Brackets

X. Overhead Construction Standard 385, Weathering and Galvanized Steel Crossarms

XI. Overhead Construction Standard 825, Horizontal Conductor Spacing – General Information

XII. Electric Transmission & Distribution Engineering 12100

XIII. California Public Utilities Commission, General Order 95

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SCOPE: This standard provides criteria for the proper use of primary conductors in overhead construction.

1. Span Lengths

   Care should be taken when changing from vertical configuration to triangular or horizontal configuration so that pin spacing is not reduced. Long spans should be avoided in this situation. See Overhead Construction Field Maintenance Only Standards Section 499 for span lengths required when using vertical construction.

2. Reduced Tension Spans

   Reduced tension construction is used only when adequate guying cannot be installed. The installation of conductor at reduced tension should be avoided. Keep reduced tension span conductors in the same relative position at both ends of the span (i.e. do not change from horizontal to vertical construction in a reduced tension span).

3. Mixing Copper and Aluminum Conductor

   Do not use aluminum and copper conductors in the same span. The dissimilarity in sag can cause conductors to slap together and result in service interruptions.

4. Conductor Protection

   Weatherproof copper wire is no longer installed on primary, series, or secondary circuits. All cutovers from 4 kV to 12 kV on the main feeder should not use existing weatherproof wire for 12 kV. Specify bare copper or ACSR/AW conductor on all future work orders and replace services where insulation is missing.

   Line guards are to be installed over 5005, ACSR, or AWAC conductors on distribution circuits at all pin, clamp top or suspension supports. See Overhead Construction Standard 759.

5. Primary Neutral Conductor

   In addition to jobs issued specifically to install a primary neutral conductor on the primary overhead system, primary neutral conductors shall be included or poles shall be framed for primary neutral conductors in the following jobs:

   a. The fourth conductor (primary neutral) shall be installed on all new or reconductored distribution feeders. If the primary neutral conductor cannot be connected to the substation ground without major expense, an existing grounding bank neutral shall be considered (see Filed Maintenance Only (FMO) OH1194 for grounding bank information).It is preferable that a fourth wire/primary neutral is connected to the substation.

   b. The primary neutral shall have a ground every 1000 feet or less if only steel poles are within that distance. If steel, wood, or composite poles exist within the 1000-foot distance only steel poles shall be grounded. If there are only wood or composite poles within the 1000-foot distance none of the poles shall be grounded. All equipment shall be grounded. Grounded equipment and cable poles do not count toward the ground every 1000 feet requirement.

   c. Circuits that operate at 12,470 volts wye (Mountain Empire District), where the primary neutral extends from the substation, shall have a ground every 1000 feet or less if only steel poles are within that distance. If steel, wood, or composite poles exist within the 1000-foot distance only steel poles shall be grounded. If there are only wood or composite poles within the 1000-foot distance none of the poles shall be grounded. All equipment shall be grounded. Grounded equipment and cable poles do not count toward the ground every 1000 feet requirement.

   d. All new or reconductored distribution feeders, starting at the substation, shall be designed and framed for the primary neutral.

   e. The primary neutral conductor is not required on a two-wire distribution tap/lateral.

   f. The Neutral conductor shall be appropriately labeled as primary neutral "PN" or Common Neutral "CN".

Depending on the current circuit /conductor configuration the primary neutral can be installed in the outside or inside pin position.

Installation problems may exist when installing a primary neutral conductor on an existing vertical pole due to primary conductor position as

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The primary neutral conductor should be installed on the inside position closest to the pole. However, field conditions and construction needs should be considered as there may be pole top arrangements where placement of the primary neutral conductor in an outside position would be safer.

If existing construction has the primary neutral on the inside position, then the primary neutral should continue to be located on the inside position for a job that extends the circuit from the point the primary neutral stopped on the existing circuit.

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SCOPE

This design standard provides criteria for the proper use of secondary and service conductors in overhead construction.

CRITERIA

A. Overhead Services

1. Check for legal clearance.
2. Check the size of the customer's panel and customer load requirement to determine the appropriate conductor size.
3. Determine service points for street light services.
4. Triplex/quadruplex conductor shall be installed for new services.
5. Upon inspection, if the existing gray wire conductor covering is damaged, deteriorated, or requires splicing it shall be replaced with triplex/quadruplex conductor.
6. If the existing secondary is open wire and there is a single pole to be changed out, the open wire can remain and splicing is permitted.
7. If existing service is bare wire or #2 or smaller gray wire, and needs to be replaced or requires splicing, it shall be replaced with triplex/quadruplex conductor (see OH711, Wire Tables, for ampacity requirements).
8. Use copper service wire within one mile of Contamination District 1 or within five miles from the coast (see OH711, Wire Tables, for ampacity requirements).

B. Low Services

1. The following recommended procedures may be used to obtain legal clearances for services:
   a. Pull slack from conductors and services.
   b. Remove buck arms and install triplex/quadruplex services on ends of line arms.
   c. Interset service poles to obtain required clearance. Set clearance poles on customers' property when no other option exists.

REFERENCES

I. Overhead Construction Standard 711, Wire Tables

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SCOPE

This design standard provides the requirements for submitting electric load studies for load additions to the overhead and underground electrical distribution system.

CRITERIA

A. Electric Load Studies are required for any new load addition which puts the existing and new load above the Transformers nameplate rating or an addition of load through a Primary Metered system.

B. Items required to process Electric Load Studies:

1. Load studies for 1 MW or greater must be reviewed and approved by the Electric Distribution Planning (EDP) Team.
2. The EDP Engineer reviews and approves the specified circuit or circuits required to serve the load additions on the load study.
3. To control new loads added to 4 kV circuits, any 4 kV station greater than 500 kVA requires review and approval from EDE, via EDE's Deviation Request process. During this approval process EDP is looped in for comment and approval.
4. For Primary Metered (PM) load additions, the EDP Engineer will review and approve the load addition and selected circuit.
5. The Customer Project Planners will submit a Fusing Request that is in conjunction with the load study.
    a. Both the Load Study and Fusing Request require approval, before the project can move forward.
    b. If an MVI switch is proposed, it requires approval by either a Fusing Specialist in EDP or by the System Protection team. See OH1435.1 or UG4235.1.
6. The Customer Project Planners load study submital shall include, but is not limited to the items listed below:
    a. All new or added load in 'kW' to the system or impacted transformer.
    b. Location including substation, circuit and existing transformer/station number, if known, where the load is being proposed.
    c. Description of the new load addition including but not limited to:
        1) General Base Load
        2) Type of charger for Electric Vehicle
        3) Electrification
        4) Solar/Batteries
        5) Motors
            a) Motors of 25 horsepower or larger, and all elevator motors, where the intended use of motor and number of starts per hour per day is specificied.
    d. For additional items within the load study, please reference Service Planning Manual 392, Load Studies, Gas and Electric.

REFERENCES

I. Service Planning Manual 392, Load Studies, Gas and Electric

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B	Revised	CSE	MVM	FRC	CZH	11/9/2020	E						
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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

ELECTRIC DISTRIBUTION LOAD STUDY

SCOPE

This design standard provides guidelines for the evaluation of spans for phase spacing.

CRITERIA

When a span of the overhead electric distribution system has been identified as having the potential to have phases slap together, the following steps should be followed to correct the problem. These guidelines apply to spans with three or four conductors.

A. Correctly sag the conductors.

B. Increase phase separation on the existing crossarms or apply longer crossarms (if feasible). Apply OH1655, "4-Wire Tangent Two Levels" or OH474 "Deadending Conductor Center-Phase" configuration should be considered.

C. For existing construction only, apply spacers until Item B, above, can be completed. Spacers should be installed as close to the middle of the span as possible. It is possible that spacers could still be applied on existing spans even if phase separation is correct depending on environmental conditions (i.e., high wind area, long span). Spacers may also be used for freeway crossings if phase separation is an issue.

   The following factors regarding spacers should also be considered when determining if they can be used:

   1. Spacers shall not be used on new construction without a deviation request approved by Electric Distribution Engineering.
   2. Spacers are helpful in maintaining mid-span phase conductor separation in cases where dissimilar conductors exist (size or type differs). Regardless, spacers applied in this manner are an interim measure until a permanent solution is completed (re-build, reconductor, re-route, undergrounding, etc.).
   3. Spacers will add wind loading and weight to the line. Spacers will also expedite the accumulation of ice in areas subject to extreme winter weather.

Listed below, in Table 1, are guidelines for span length and conductor size.

TABLE 1: MAXIMUM SPAN LENGTH VS. CONDUCTOR SIZE

Span Length (FT)	Smallest Conductor Size in Span
Less than 600	#2 ACSR or smaller or #4 Copper
600 to 799	3/0 ACSR or smaller or #2 Copper or smaller
800 to 999	336 ACSR or smaller or #1/0 Copper or smaller
1,000 or longer	Deviation Request Required

Attention: Refer to OH755 for spacer installation instructions. Bucket truck access to the spacer location is required. More than one spacer may be installed within a span if bucket truck access to the middle of the span is not possible.

Helicopter application of distribution phase spacers is not feasible.

REFERENCES

I. Overhead Construction Standard 474, Deadending, Center Phase Conductor Delta, Wood and Composite Crossarms

II. Overhead Construction Standard 755, Fiberglass Conductor Spacer

III. Overhead Construction Standard 800, Overhead Sag and Tension Standards

IV. Overhead Construction Standard 1655, Crossarm Construction – 4-Wire Tangent Two Levels – Avian Safe Construction

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

DISTRIBUTION PHASE SPACING

DM5129.1

SCOPE

This design standard provides guidelines for selecting locations to install warning spheres on overhead lines with voltages between 0 and 22,500V in authorized boat operating and launching areas.

DEFINITION

- Nautical Craft – A boat/raft/dredge/barge/etc., with a mast, antenna, or superstructure that, when erected, would extend vertically above 14ft-3in from the ground or body of water.

CRITERIA

A. Warning spheres shall be installed on overhead lines, at the discretion of SDG&E, when:

1. Physical evidence.
2. Together with personal observation.
3. Notification from the public suggests that nautical craft may come within 20ft of energized conductors (0 – 22,500V) while being operated or preparing for operation with the mast, boom, antenna, or superstructure erected.

B. This applies, but is not limited, to the following locations:

1. A designated nautical craft launching area or driveway to such area.
2. A body of water that is frequented by nautical craft as evidenced by posted signs, personal observation, or notification from the general public.
3. A nautical craft storage facility.

APPLICATION

A. The Customer Project Planner shall submit a Deviation Request for investigation whenever an Overhead Conductor requires warning spheres, as specified in the guidelines above. Electric Distribution Engineering in conjunction with ERO leadership shall determine whether the conductor should be protected with warning spheres according to OH325 or whether the line should be either relocated or converted to underground based on cost and physical limitations.

REFERENCES

I. California Vehicle Code, Section #35250

II. Overhead Construction Standard 325, Boat Launching Area Warning Sphere

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

WARNING OF OVERHEAD CONDUCTORS BOAT OPERATING – LAUNCHING AREAS

DM5131

SCOPE

This design standard provides a guideline for selecting locations to install warning spheres on overhead lines with voltages between 0 and 22,500V in authorized aerial areas.

CRITERIA

A. All line designs will comply with the SDG&E Aerial Lighting and Marking (AL&M) Policy. Pole designs will be submitted to the SDG&E AL&M group using the access database AL&M Review Form (see Figure 1), located in the TED SharePoint Site; TED Applications[I]. This is used to determine whether FAA lighting and marking requirements apply.

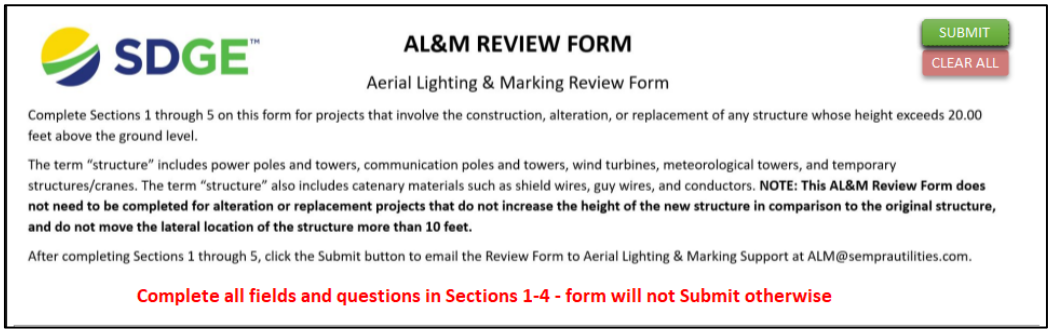


Figure 1
AL&M Review Form Headings

B. Where marker balls are deemed necessary, and all alternative height reduction options have been evaluated, marker balls will be incorporated into the design using OH330, Aviation Marker Warning Sphere. Standard structure configurations may need to be modified to accommodate marker ball spans if separate dedicated marking structures are deemed infeasible.

APPLICATION

A. The Customer Project Planner shall submit a Deviation Request for investigation whenever an overhead conductor requires warning spheres, as specified in the guideline above. Electric Distribution Engineering in conjunction with ERO leadership shall determine whether the conductor should be protected with warning spheres according to OH330, Aviation Marker Warning Sphere, or whether the line should be relocated or converted to underground based on cost and physical limitations.

MARKER BALLS

A. Marker balls shall be installed when recommended by the Aviation Services group based on the completion and analysis of the Aerial Lighting and Marking (AL&M) form.

B. PLS-CADD will be used to check design spans that require marker balls. The PLS-CADD designer will create the marker balls as point loads in the PLS-CADD model and determine that minimum clearance standards are met once the marker balls have been attached. The PLS-CADD designer will check design spans with marker balls for structure loading. Marker balls are a significant adder to the transverse wind loading. The PLS-CADD designer will rerun structure checks once marker ball point loads are modeled. Be aware if the class of pole needs to change.

C. See SDG&E Aerial Lighting and Marking (AL&M) Policy and OH330, Aviation Marker Warning Sphere.

NOTES

I. Access to the AL&M SharePoint may be requested to TED.

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

WARNING OF OVERHEAD CONDUCTORS AERIAL LIGHTING AREAS

DM5132.1

REFERENCES

I. California Vehicle Code, Section #35250

II. Overhead Construction Standard 330, Aviation Marker Warning Sphere

III. SDG&E Aerial Lighting and Marking (AL&M) Policy

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SCOPE

This design standard references the designated avian protection critical areas and those standards and publications which provide guidance for the application of avian-safe construction.

The SDG&E Avian Protection Plan (APP) was approved and implemented in January 2005. The APP was developed in a partnership between the Departments of Land Planning and Natural Resources and Electric Distribution Engineering. Following this plan assures that SDG&E follows its 50-year environmental permit and Federal laws that protect both raptors and all migratory birds.

The SDG&E **OH Construction Standards Section 1600** was developed to outline the APP guidelines and ensure compliance is met and maintained.

REFERENCES

I. Overhead Construction Standards Section 1600, Wildlife Protection

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5200
UNDERGROUND
LAYOUT SYSTEMS

5200
UNDERGROUND
LAYOUT SYSTEMS

PAGE	SUBJECT
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5215	JURISDICTIONAL DESIGN REQUIREMENTS
5220	RESIDENTIAL PRIMARY SYSTEM DESIGN (NORMALLY OPEN LOOP SYSTEMS) (COMING SOON)
5221	COMMERCIAL / INDUSTRIAL PRIMARY SYSTEM DESIGN (NORMALLY OPEN LOOP SYSTEMS)
5222	SINGLE-FAMILY RESIDENTIAL SECONDARY AND SERVICE DESIGN CRITERIA
5227	COMMON G.O. 128 INFRACTIONS
5228	UNDERGROUND CABLE IMPEDANCES (COMING SOON)
5229	UNDERGROUND CABLE INSTALLATION CRITERIA
5231	TRENCH POSITION REQUIREMENTS
5233	CABLE PULLING TENSIONS, PRIMARY AND SECONDARY (COMING SOON)
5234	CABLE TAIL LENGTH REQUIREMENTS
5236	SIGHT DISTANCE REQUIREMENTS
5240	UNDERGROUND SYSTEM EQUIPMENT SELECTION AND LOCATION
5250	UNDERGROUND SECTIONALIZING EQUIPMENT

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C	Added 5215 & 5229	-	JES	FRC	KRG	01/08/2025	F	Editorial	JIK	JIK	-	-	05/21/2025
B	Formatting	-	JIK	-	-	02/21/2020	E	Editorial	JIK	DJB	FRC	KRG	02/25/2025

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SCOPE

This design standard provides guidelines associated with the design and construction on the distribution underground systems.

DEFINITIONS

- EDP – Electric Distribution Planning
- Electrification - Process of powering by electricity and is typically used in the context of replacing technologies that use fossil fuels with those that use electricity.
- SCADA - Remote Switching, which also gathers information (Temperature, Voltage, Current, etc.) for distribution planning.
- TELCO – Communications Company
- QEW – Qualified Electric Worker

CRITERIA

A. Customer Load Information

SDG&E's Customer Project Planner determines the appropriate layout, load and service voltage for customers using the demand estimating criteria from DM5322 and DM5311. Ultimately, the secondary service voltages will depend on the existing distribution system and will adhere to the voltage levels specified in Rule 2, Description of Service.

Note: Determining the customer's service voltage early in the process is essential for selecting the appropriate materials and equipment for the design. Additionally, identifying Long Lead Time items early-on is crucial to ensure that all necessary materials are available when construction begins. This proactive approach helps avoid delays and ensures a smoother project timeline.

B. Job Location

It's important to consider the project location early in the planning phase. All projects should be field verified with the Planner and, if available, a Qualified Electrical Worker (QEW) or someone with field experience. An on-site field inspection should provide the following:

1. Existing facilities (distribution, gas, and TELCO)
2. Identify and note possible conflicts.
3. Elevations, if grading has started.
4. Potential for future developments.

C. Distribution Planning Work Sheet

1. Account for electrification
2. Number and size of primary feeder circuits (cable and conduits).
3. Any sectionalizing requirements (switches and fuse sizes).
4. Special requirements for extra ducts, such as allowances for SCADA cables.

Attention: The Customer Project Planner should design the project in accordance with the area's feeder requirements. Collaborate with the EDP Engineer to determine these feeder requirements.

D. Location of Load

1. Locate the transformer closest to the load. Verify that the voltage is correct and ensure that the combined total of the new load and the existing load complies with the loading tables in DM5621.
2. Route primary cable and conduit as necessary.
3. Size secondary or service cables, see UG4012.
4. Determine the secondary and service conduit size, minimum of 3". See UG3372, UG4002 and UG4004.

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5. Provide secondary substructures, if needed.

Attention: Three-phase loads should not be served by combining three separate single-phase cables from different single-phase sources. Instead, they should be served by three single-phase cables from a common three-phase source at the location where three-phase service is required.

E. Energy Source

The energy source needed to energize the primary system will be one of the following:

1. Underground source
   a. New underground structure
   b. Old underground extension
2. Substation circuit feeder
3. Trenching to cable poles or existing facilities

Attention: As a general rule, the applicant/contractor will be allowed to complete the trench and installation of conduits and/or substructures.

F. Secondary Systems

A secondary system is the distribution system between the transformer and the last connection point of service before connection to the customer's service panel. The customer project planner should take into consideration the following when designing a secondary system:

1. Electrification & load growth
2. Distance between service point (metering facilities) and transformer.
3. Voltage drop & voltage flicker
4. Locating secondary substructures
5. Conduit sizing, see UG4012.
   a. Conductor size
6. Pulling tension
7. Service trenches

   The following are acceptable service trench positions:

   a. Figure 1 shows the preferred service trench layout when the grade differential between lots is less than 3'. The service trench may be installed on either side of a common lot line according to field conditions with the customer project planner's or inspector's approval.

   b. Figure 2 shall be used when the grade differential between lots is 3' or more. If applicable, the gas service trench location will be determined by the customer project planner or inspector for joint installation.

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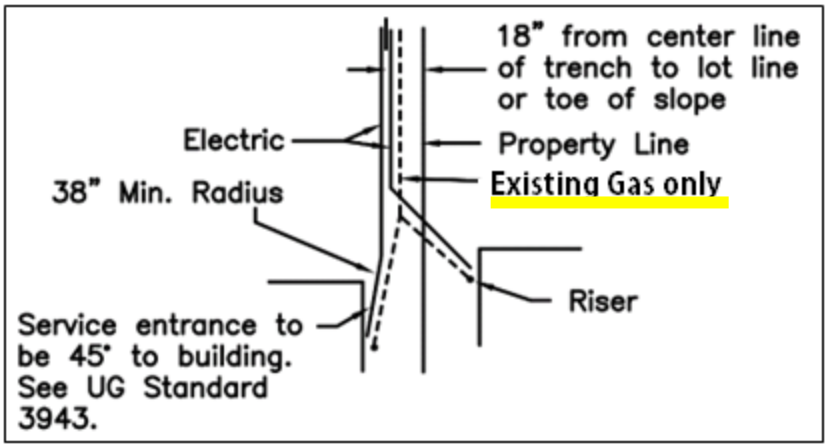


Figure 1
Preferred Service Trench Layout

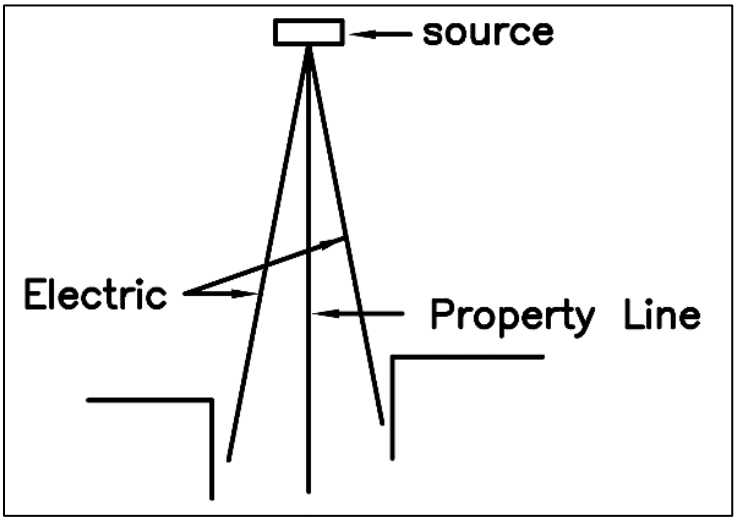


Figure 2
Service Trench Layout for Mismatched Grades

G. Primary System

An underground primary system is an electrical system from a primary voltage source (12 kV, 7.2 kV, 6.9 kV, 4 kV, or 2.4 kV) to one or more primary transformers depending on the type of development to be served. In designing an underground primary system, the customer project planner should take into consideration the following:

1. Transformer location (or point of service for primary-metered customers)
   a. Single-family residential
   b. Multi-family residential or commercial

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2. Transformer Type (Residential or Commercial)
    a. New developments
        1) Residential
            a) Single Phase
                (1) H-Type for new developments (240V/120V)
            b) Three Phase
                (1) HBS-Type (280V/120V)
        2) Commercial
            a) HBS-Type (280V/120V)
            b) HNS-Type (480V/277V)
        3) See UG3702
3. Primary Cable
    a. Single-family or multi-family residential
    b. Commercial
    c. Cable Pulling
4. Primary Structure Locations
    a. Single-family residential
        1) Substructure
        2) Conduit and trench
    b. Multi-family residential or commercial
        1) Substructure
        2) Conduit and trench
5. Connections
    a. Loadbreak capable

H. Protection - See DM6100 - Sectionalizing and Protection for further details.

When designing a primary system, the following protective devices for the primary electric system should be provided:

1. Fault interrupting equipment
2. Fused switching cabinets on distribution branch and branch taps.
3. Fused elbow connectors
4. Transformer fusing
5. Reclosers of fuse cutouts on poles.

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REFERENCES

I. Electric Distribution Design Manual 5211, Underground Design Process Guideline

II. Electric Distribution Design Manual 5127, Electric Distribution Load Study

III. Electric Distribution Design Manual 5231, Trench Position Requirements

IV. Electric Distribution Design Manual 5322, Residential Demand Estimating

V. Electric Distribution Design Manual 5611, Single-Phase Transformer Application

VI. Electric Distribution Design Manual 6100, Sectionalizing and Protection

VII. Underground Construction Standards 3372, Conduit Sizing for Underground Cables

VIII. Underground Construction Standards 3700, Transformers

IX. Underground Construction Standards 4000, Cables

X. Service Planning Manual (SPM):

1. SPM 204, Customer Cost Responsibility – Rule 15/16 Extensions & Upgrades
2. SPM 240, Gas and Electric Line Extensions and Service/Meter Requirements for Subdivisions / Development
3. SPM 280, Three Phase Facilities
4. SPM 341, Design Procedure
5. SPM 1025, Engineering Field Check Request Opening Structures

XI. Electric Rule 2 – Description of Service

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SCOPE

This design standard lays out typical design requirements for work requiring a Right of Way permit in the City of San Diego. Please note, additional design requirements beyond the items listed below may be needed to obtain a Right-of-Way permit from the City of San Diego.

DEFINITIONS

- Right of Way (ROW) - shall mean the publicly dedicated right-of-way of the CITY, which are public easements for streets, alleys, or other uses, as defined in San Diego Municipal Code section 113.0103, as may be amended from time to time.
- Excavation - shall mean the act, process, or result of earthen material or substance being removed, cut into, dug, quarried, uncovered, displaced, or relocated.

CRITERIA

The following should be considered when preparing a design for excavation in the City of San Diego's Right of Way.

A. Design Requirements

1. Vicinity map (no aerials)
   a. Street names should be clear.
   b. The job site should be identified with a call out.
2. Identify facility ID numbers.
3. North Arrow
4. Fully dimensioned set of plans, including font and scale requirements.
5. Identify address numbers of properties adjacent to work.
6. Identify legal description of the property (i.e., lot number, block number, subdivision name, map number and assessor's parcel number) and property Owner's name if project is for a specific property.
7. Identify street names.
8. Show and call out all **existing site conditions**. Dimensions and separations may be required to be called out. Including, but not limited to:
   a. Utilize City civil symbols.
   b. Identify curb and gutter location.
   c. Identify curb-to-property line distance.
   d. Dimension existing and proposed sidewalk (if any).
   e. Dimension front and side property lines.
   f. Location and width of the existing proposed driveway(s).
   g. Location of Existing utilities (show the type, size, and separation).
   h. Identify existing landscape/non-standard improvements in the parkway (if any).
   i. Identify the ROW width (R/W to R/W).
   j. Identify designated bike lanes.
   k. Identify driveways, utility boxes, fire hydrants, trees, curb ramps, street signs, any other existing private requirements.
9. Show and call out **proposed work**. Dimensions and separations may be required to be called out. Including, but not limited to:
   a. If retaining wall is proposed, detail of retaining wall is required.

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b. For poles, identify distance from existing to proposed pole, proposed pole to property line and face of curb, proposed pole to any nearby driveway flare, proposed pole to any trees, edge of pole to edge of sidewalk (if any) to determine walkway clearance.

1) 18in to be maintained from face of curb to edge of pole.

c. If the existing poles have guy wires & anchors or a streetlight attached, call out if it is to be transferred to the new pole or removed.

d. For pipes, identify size and length of proposed trenching, any RFS, and specify if it to be abandoned in place or removed from ground.

e. If concrete panels are being disturbed, show concrete joint lines for applicable panels.

B. Horizontal Separation Requirements

NOTE: Horizontal separations are to be measure from edge to edge. For example, from the edge of SDG&E utility to edge of other utility/structure (e.g., edge of gas pipe to edge of water pipe, edge of pole to edge of driveway flare). If minimum separation cannot be met, an approval from governing jurisdictions, agencies and disciplines will be required. This could include Water and Sewer (PUD), Landscape, etc. This may lengthen the review process.

1. Show and call out the required clearances from existing improvements to new underground structures. Minimum required separation for **underground** structures:

a. 10ft preferred; 5ft may be accepted to Sewer Mains (wet utilities)

b. 10ft preferred; 7ft may be accepted to Sewer Manhole

c. 10ft to Recycled Mains

d. 5ft to Water Mains

e. 5ft to Storm Drains

f. 5ft to Storm Drain Structures (i.e., curb inlets and cleanouts)

g. 5ft to all valves

h. 5ft from existing street tree

i. 1ft to other telecom and gas utilities

j. 3ft from face of curb (preferred)

k. 3ft to sewer lateral (service)

l. 5ft to water service

2. Show and call out the required separation distances from any existing improvements to new above grade structures. Minimum required separation for **above grade** structures:

a. 4ft walkway clearance per ADA requirements (If the 4ft minimum clearance cannot be met add sidewalk pop out to accommodate the 4ft clearance.)

b. 3ft to driveway flare (edge of structure to edge)

c. 10ft preferred; 5ft may be accepted to Sewer Mains (wet utilities)

d. 10ft preferred; 7ft may be accepted to Sewer Manhole

e. 10ft to Recycled Mains

f. 5ft to Water Mains

g. 5ft to Storm Drains

h. 5ft to Storm Drain Structures (i.e., curb inlets and cleanouts)

i. 5ft to all valves

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j. 10ft from an existing street tree

k. 1ft to other telecom and gas utilities

l. 3ft to sewer lateral (service)

m. 5ft to water service

C. Common Notes

1. Add a disclaimer for notes that give direction to contractors, not for permit:

   a. SPECIAL NOTES: THE FOLLOWING NOTES ARE PROVIDED TO GIVE DIRECTION TO THE CONTRACTOR BY THE ENGINEER OF WORK. THE CITY ENGINEER'S SIGNATURE ON THESE PLANS DOES NOT CONSTITUTE APPROVAL OF ANY OF THESE NOTES AND THE CITY WILL NOT BE RESPONSIBLE FOR THEIR ENFORCEMENT.

2. Add note when a driveway is being disturbed, add to the notes section:

   a. FOR WORK BEING PROPOSED IN A DRIVEWAY, ALL CONCRETE PANELS BEING DISTURBED SHALL BE REMOVED AND REPLACED FROM JOINT TO JOINT AND RESTORED TO THE ORIGINAL CONDITION. IN CASE THE ADJACENT CONCRETE PANELS ARE BROKEN/DAMAGED/LIFTED THAT CAN CAUSE A TRIPPING HAZARD, THEN THE CONTRACTOR SHALL EXTEND THE RESTORATION TO INCLUDE THE BROKEN/DAMAGED/LIFTED PANELS, TO THE NEAREST JOINT.

3. If any work is near entrance to private property (driveway or private walkway), add note:

   a. BEFORE STARTING ANY WORK OR CONSTRUCTION ACTIVITIES THAT WOULD INTERFERE WITH PRIVATE PROPERTY, PLEASE COORDINATE WITH PROPERTY OWNERS PER SECTION 10-D OF THE CITY OF SAN DIEGO'S MOU WITH SDG&E.

4. If any work is shown inside private property, add note:

   a. WORK ON PRIVATE PROPERTY FOR REFERENCE ONLY AND NOT PART OF PERMIT.

5. If impacting concrete panels, add restoration note:

   a. CONCRETE PANELS BEING DISTURBED SHALL BE REMOVED AND REPLACED FROM JOINT-TO-JOINT PER CITY STANDARDS.

6. If potentially proposing boring in-lieu of open trench, add note:

   a. BORING IN-LIEU OF OPEN TRENCH MAY BE A PREFERRED CONSTRUCTION OPTION DURING CONSTRUCTION. BORING WILL NOT PROPOSE ANY ADDITIONAL SCOPE OF WORK AND WILL NOT ALTER THE TRENCH LINE ALIGNMENT AND ELEVATION.

REFERENCES

I. City of San Diego Administrative Memorandum of Understanding with SDG&E Regarding Gas and Electric Franchise Agreements

II. San Diego Municipal Code Chapter 14, Article 2, Division 4

III. San Diego Municipal Code Chapter 11, Article 3, Division 1

IV. City of San Diego Sewer Design Guide 2015

V. City of San Diego Water Facility Design Guidelines 2021

VI. City of San Diego Street Design Manual 2017

VII. City of San Diego Information Bulletin 165

VIII. City of San Diego CADD Standards and Drafting Files

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SCOPE

This design criteria establishes a looped distribution system which is fused when required by the transformer size.

PURPOSE

The looped local distribution system allows a troubleshooter to restore service to all but two transformers by operating 200 amp loadbreak elbows. Transformers which are too large to be fused are served from the feeder system.

DEFINITIONS

Loop Design – Incorporates a fused local distribution cable. Therefore, this design is limited for fusible transformers whose total connected KVA does not exceed the fuses' capability.

Lot Development Design – Combines the loop design for fusible transformers with radially fed transformers which are too large to fuse.

Commercial Load Forecast – Provides an ultimate demand estimate for a commercial or industrial building constructed in a lot development project when no developer load information is provided.

Residential Looping Criteria – Provides minimum looping criteria for single-family and multi-family residential developments.

CRITERIA

A. General Design Criteria for Commercial and Industrial Systems

The commercial/industrial primary system design was based on an ACO (Annual Cost of Ownership) economic analysis that determined the minimum system requirements and particular equipment layout. All fusible transformers shall be attached to the looped local distribution system; however, large transformers are served radially from the feeder system.

1. The primary system shall be designed in accordance with this standard whenever three or more transformers totaling at least 450 KVA will ultimately be required.

2. The transformer size may be estimated from the Commercial and Industrial Demand Estimating Criteria (Design Standard 5311) or the Commercial Load Forecast Criteria provided in Section D of this standard.

B. Loop Design

The loop design is limited to fused local distribution cable. Transformers which are too large to be fused are served radially from the feeder. This method used to serve large transformers is detailed in Section C "Lot Development Design."

1. The loop design may be constructed through loop-feed transformers (Figure 5) or the transformers may be served radially from a looped local distribution cable installed in the street (Figure 6).

2. No more than two transformers may be served from a radial cable and no more than two radial cables may be connected to a cable tap (Figure 6). In the event of an outage, a troubleshooter shall be able to restore service to all but two transformers by isolating the damaged equipment.

3. The Molded Vacuum Interrupter (MVI) shall not be installed on underground circuits that connect to an open point on the same circuit or an open point that creates a tie with another circuit.

4. Transformers 1500 KVA and larger may not be attached to the fused loop design (Figure 8).

5. A single fuse cabinet loop design (Figure 1) can serve up to 2080 KVA. A two fuse cabinet loop design (Figure 3) can serve up to 3120 KVA.

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NOTE: Use #2 AL cable for a single fuse cabinet loop (Figures 1 & 2) and use 2/0 AL cable for a two fuse cabinet loop (Figure 3).

6. The loop design does not have to be completed on the initial wok order if future job(s) will ultimately complete the looped local distribution cable.

7. The preferred fused device, because of its lower install cost, is a cable pole which is not subject to future removal. However, a fuse cabinet is acceptable in all situations.

8. The local distribution cable's circuit length shall be at least twice as long as the feeder line segment it surrounds (Figure 4). This prevents the loop design from sharing too much load when the loop is in parallel with the feeder.

9. Surface operable loadbreak equipment shall be used within the loop design. Therefore, manholes may only be used to aid cable pulling within the loop and supply a fuse cabinet that serves the loop.

10. Each loop design shall have:

    a. A single normally open point located at the load center.

    b. A single normally open point located at the point furthest from the single fused device (Figures 1, 2 & 3). The normally open point shall be tagged "normally open loop" and preferably not located within a transformer compartment.

C. Lot Development Design

A lot development design is completed before the developer has provided connected load information. The estimated demand per lot is determined from the Commercial Load Forecast of Section D.

1. All lots shall be supplied with a 4" conduit stub.

2. A 4" loop conduit system shall be installed in the street for the fused local distribution system.

3. A 5" loop conduit system shall be installed in the street when at least 2000 KVA will be served on an unfused cable (Design Standard 6232). A 4" radial conduit system is sufficient when a single 1500 KVA transformer will be served.

4. Lots which may be served with unfused cable (Greater than 1000 KVA) shall be provided with two 4" conduit stubs in case the lot is subdivided prior to the installation of electric facilities. Each stub shall originate from a substructure that will permit the transformer(s) to be served from fused cable while only one stub must allow connection to unfused cable.

5. A combination of lots which, if constructed as a single lot, may require unfused cable (Greater than 1000 KVA) shall be provided with a 4" conduit stub originating from a substructure that will permit the transformer(s) to be served from either fused or unfused cable.

6. Substructure/conduit configurations shall be able to serve lots on both sides of the street if the land is vacant on both sides of the street.

7. A fuse cabinet pad shall be placed as close to the feeder as possible (Design Standard 6121) to serve the local distribution system. More than one pad is required when the estimated fusible load exceeds 2080 KVA.

8. In most cases, a 3315 primary substructure is adequate. However, a 3316 substructure may be used when required or cost justified.

D. Commercial Load Forecast

The commercial load forecast provides an ultimate demand estimate for a commercial or industrial building constructed in a lot development project. It is based on land use information which the developer submits to the

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municipality in the form of a City Approved Design Guideline or other document.

1. Equation 1 shall be used to determine the estimated transformer size for each lot within a lot development project. The choice of system design, loop, or lot development is dependent on the estimated transformer size.

KW = SQFT x BLDCVG x MAXSTR x KWSQFT Equation 1

Where:

KW – estimated connected kW
SQFT – gross square footage of the lot
BLDCVG – maximum building coverage on the lot
MAXSTR – maximum number of building stories permitted
KWSWFT – KW per square foot given in DM 5311.6 for the type of building to be constructed

NOTE: Estimated transformer size is based on estimated KW calculation above and Transformer Selection Tables in Design Manual 5621.

a. Example 1 (Loop Design)

The developer provided information pertaining to the project shown in Figure 9 resulted in a 150 KVA transformer being selected for lots 1, 2, 6, & 7. A 300 KVA transformer was selected for lots 3, 4, & 5. Referring to the electrical layout shown in Figure 9:

1) A single fused cabinet, installed as close to the feeder as possible, is sufficient to serve the 1500 KVA project (Rule B.4).

2) A 3314 handhole, installed as close to the fuse cabinet as possible, is required to house the three way cable tops needed to start the fused local distribution system.

3) No more than two transformers, served from the fused local distribution system, are supplied from a radial cable run. The use of deadbreak tees (Lots 1, 2, 3, 4, 6, & 7) adheres to this rule while permitting the use of a radial conduit system layout (Rule B.2).

4) The local distribution system loop is created by having parallel cables running in the street between the 3315 handholes. A splice is required at lot one for cable pulling purposes.

b. Example 2 (Lot Development Project)

The following information pertaining to Figure 7 was provided by the developer on the City Approved Design Guideline:

NOTE: The gross square footage is 25,000 square feet for lots 1, 2, 3, & 5, 115,000 square feet for lot 4, and 35,000 square feet for lots 6, 7, & 8.

1) As a business park with shell building construction, a KW / Sq. Ft. of .012 was selected from Design Manual 5311.

2) An estimated load was determined for each lot using the area load forecast criteria:

300 KW – Lots 1, 2, 3, & 5

1380 KW – Lot 4

420 KW – Lots, 6, 7, & 8

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3) Estimated transformer requirements based on Design Standard 5621:

300 KVA – Lots 1, 2, 3, & 5

1500 KVA – Lot 4

500 KVA – Lots 6, 7, & 8

4) Referring to the conduit layout shown in Figure 7:

- All lots (1 – 8) are supplied with 4" conduit stubs (Rule C.1)
- Lot 4 also has an additional 4" conduit stub in case the lot is subdivided prior to installation of the electric facilities (Rule C.4)
- A 5" conduit loop is installed in the street because there is a possibility that 3000 KVA (Lots 4, 6, 7, & 8) may be served by feeder cable (Rule C.3)
- A fuse cabinet pad is provided at each end of the project (As close to the feeder as possible) because the fusible load may exceed 2080 KVA (Rule C.7)
- All primary substructures are 3316 handholes to allow connection of the loop feeder cable. 3315 handholes are adequate if a radial unfused cable is required.

5) Referring to the electrical layout shown in Figure 8:

- Lots 1, 2, 3, 5, 6, 7, & 8 are served from fused local distribution cable because the installed transformers are 1000 KVA or less.
- No more than two transformers, served from the fused local distribution system, are supplied from a radial cable run. The use of deadbreak tees (Lots 1, 2, 3, 6, 7, & 8) adheres to this rule while permitting the use of a radial conduit system layout (Rule B.2)
- The total amount of fusible load (2700 KVA) exceeds the capacity of a single fuse cabinet. Therefore, two fuse cabinets are required. The normally open point is placed at the approximate center of the load (Rules B.4 & B.10)
- Spare positions are provided from the fused local distribution at lot 4 in case the lot is split. This requires the use of a deadbreak tee serving lots 3 and 8. However, if it is known that lot 4 will not be split, the deadbreak tee may be eliminated and each transformer (Lots 3 & 8) may be served directly from the cable top (Rule C.4)
- An unfused radial cable is installed in the street to serve lot 4 because the total load connected to unfused cable is less than 2000 KVA (Rule C.3)

E. Residential Looping Criteria

New single-family homes and multi-family residential developments shall consider a primary looping system when the minimum criteria below are met.

1. Looping shall be considered when a branch will have 3 or more transformers that serve more than 350 customers, or when the branch will have 3 or more transformers that have a connected load greater than 450kVA.

2. Looping in residential systems shall be limited to 3 phase systems.

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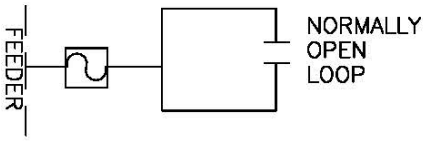


FIGURE 1

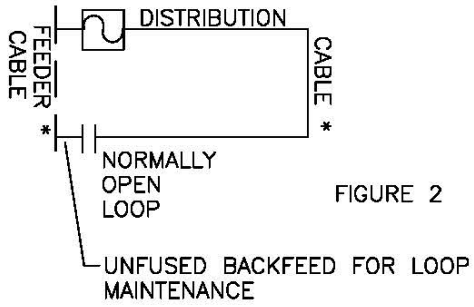


FIGURE 2

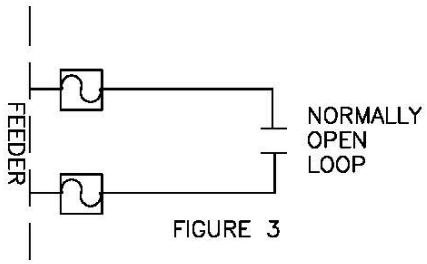
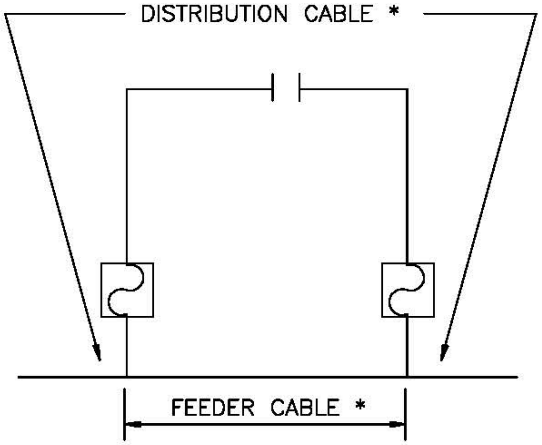


FIGURE 3



* SEE CRITERIA B.7: DISTRIBUTION CABLE LENGTH TO BE AT LEAST TWICE AS LONG AS FEEDER CABLE LENGTH.

FIGURE 4

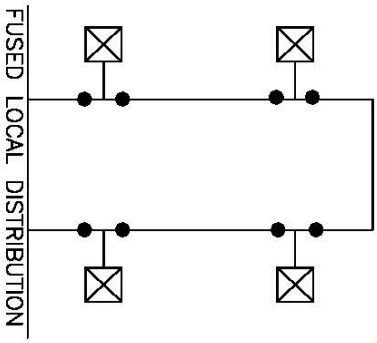


FIGURE 5

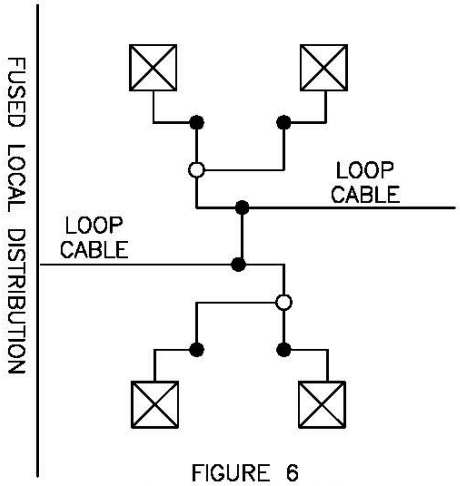


FIGURE 6
SEE CRITERIA B.2

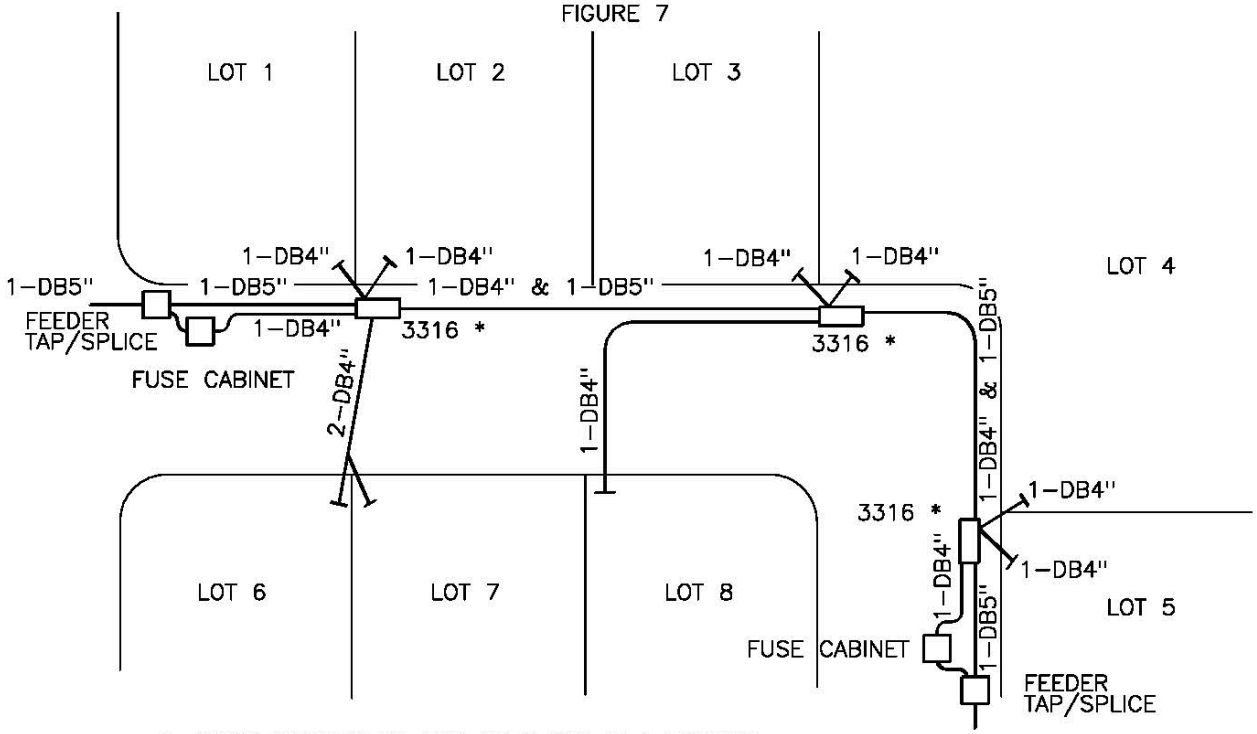
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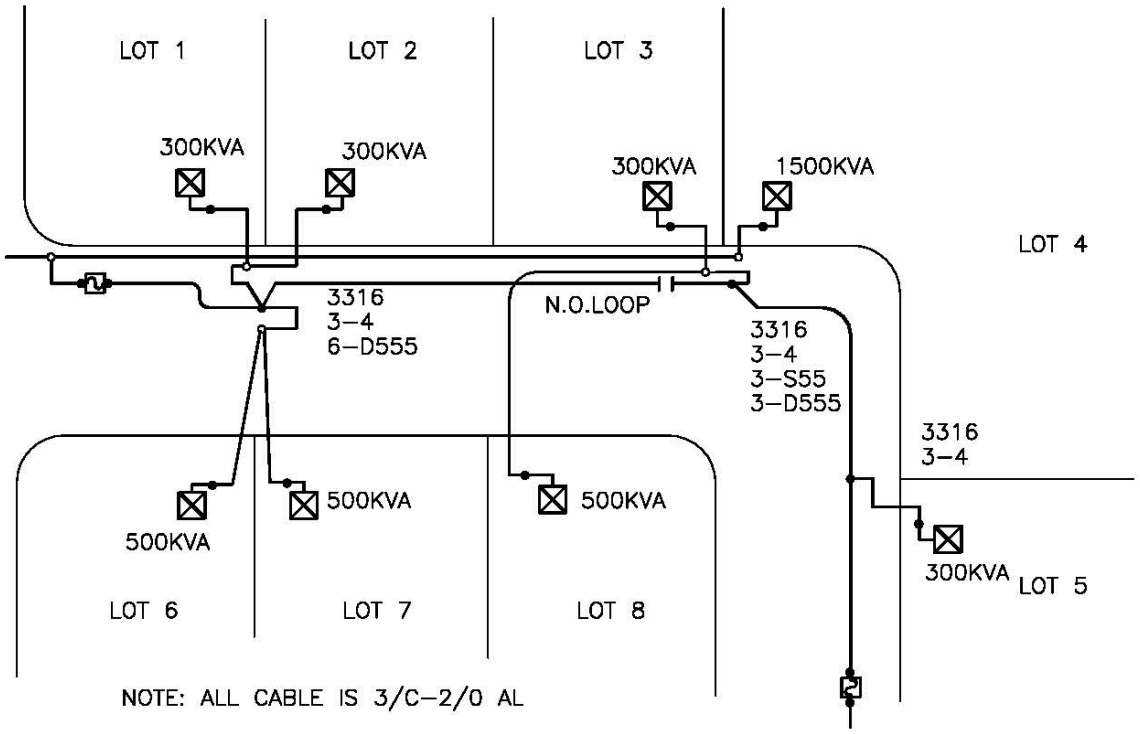
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RESIDENTIAL/COMMERCIAL/INDUSTRIAL PRIMARY SYSTEM DESIGN (LOOP SYSTEMS)

FIGURE 7



* 3315 HANDHOLES ARE ADEQUATE IF A LOOPED FEEDER SYSTEM IS NOT REQUIRED



NOTE: ALL CABLE IS 3/C-2/0 AL

FIGURE 8

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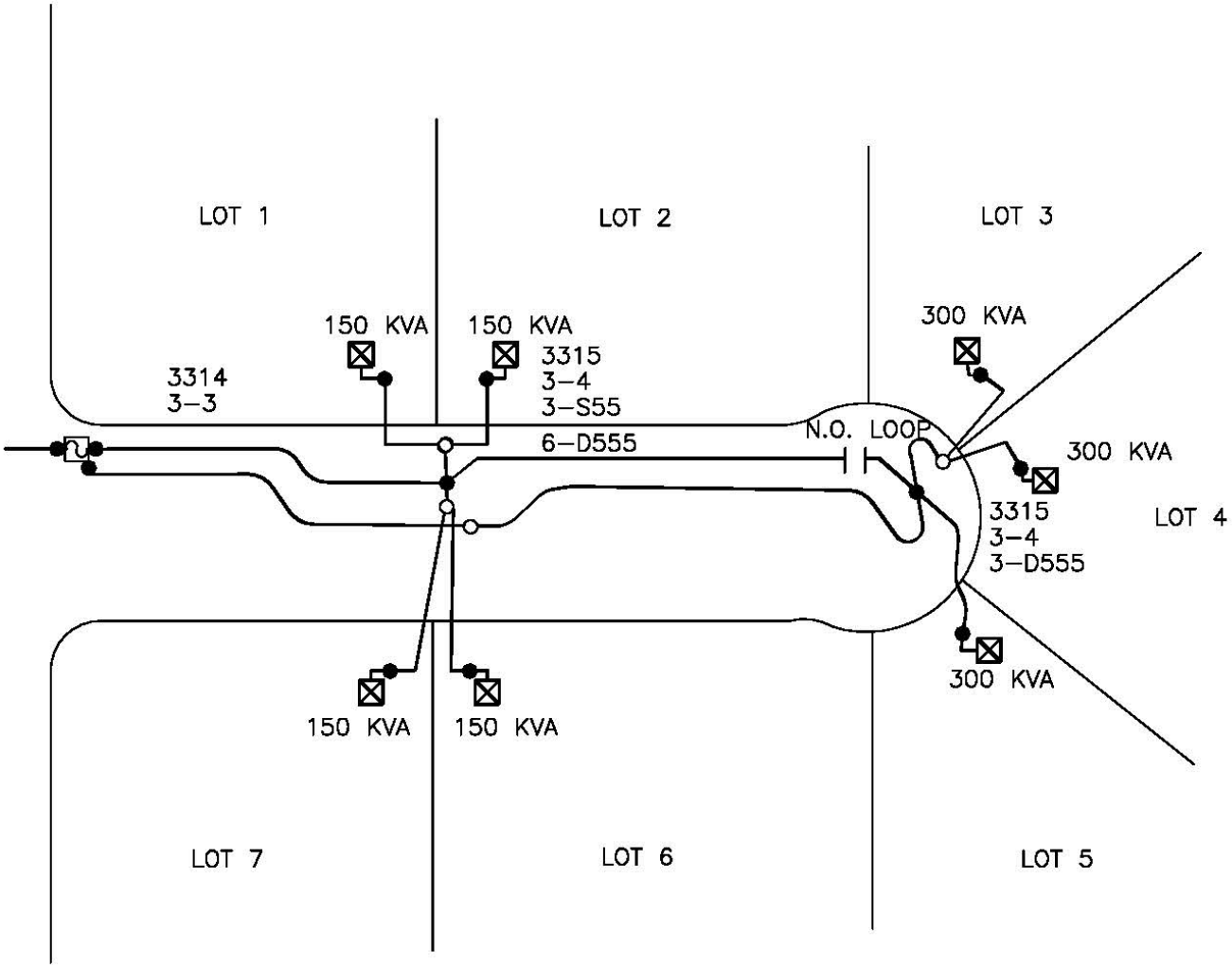


FIGURE 9

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SCOPE

This standard describes SDG&E's methodology for designing underground residential secondary and service systems.

PURPOSE

The design considerations and procedures described in this standard have been established to insure the lowest cost system design is installed.

DEFINITIONS

NONE

CRITERIA

The following design considerations and procedures shall be used for residential system design.

A. Design Parameters

1. The maximum allowable voltage drop in the secondary/service is determined by subtracting the voltage drop across the transformer from 4.2%. For example, if a 150 KVA Padmount transformer is loaded to 60% of nameplate, the voltage drop across it is 1.1% (See Design Manual 5425.2). The allowable voltage drop across the secondary/service would then be 3.1% (4.2 – 1.1 + 3.1).
2. Standard secondary able sizes shall be #2, 1/0 and 3/0 USA. The use of 350 KCML secondary cable is for exceptional cases only.
3. The use of 2 - #2 and 1 - #4 as a secondary cable is acceptable providing at least 10 percent of the total cable runs are 2 - #2 and 1 - #4.
4. Service cables are restricted to #2, 1/0 and 3/0 USA.
5. Locate the transformer and secondary handholes as close as practical to the load centers of the lots they are to serve.
6. The maximum allowable flicker is normally 6 percent. For an existing residential customer served from an existing transformer, the secondary flicker may be raised to 7% if a larger transformer would be required to meet the 6% secondary flicker limit while serving normal load.
7. The load power factor is assumed to be .9.
8. Secondary handholes shall be eliminated whenever possible as described in Design Manual 5712.

B. General Design Procedures

1. Establish the KW demand category based on the Residential Demand Estimating Criteria (Design Manual 5322).
2. The secondary distance 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 load centers to serve as many meters as possible from one location. This requires the secondary distance to span from one to four lots or the street width. Therefore, the secondary footage is determined by:

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

SINGLE FAMILY RESIDENTIAL SECONDARY AND SERVICE DESIGN CRITERIA

DM5222.1

a. Measuring the distance across the number of lots being spanned or the distance across the street.

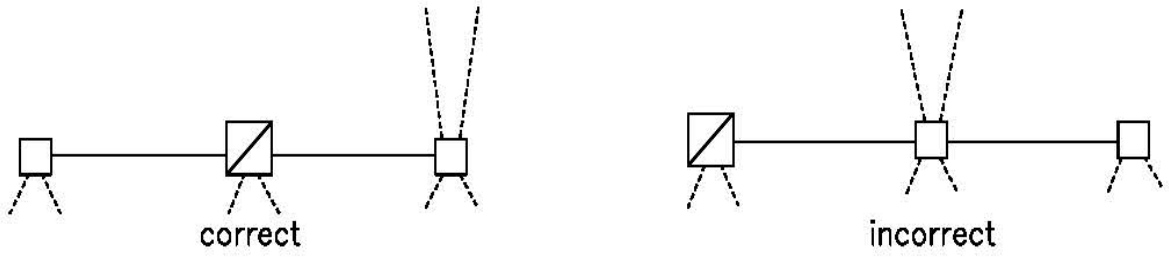
b. Adding footage to the overall distance for cable tails (See Design Manual 5922). The typical secondary distance for a subdivision should be determined by measuring several lot combinations.

3. 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 for service cable tails (See Design Manual 5922).

4. Select the subdivision single-sided and double-sided optimum array configurations from the optimum array tables (See Design Manual 5223) using 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 10 feet. Otherwise, an individual array selection must be made.

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 a cul-de-sac). The combination array must be constructed as shown below 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 handholes' capacity (Presently 6). However, the voltage drop, flicker, and transformer loading limits must be satisfied based on Design Standards 5431 and 5621.

6. When the required system configuration does not permit selection of an optimum array, the Design Parameters of this standard should be applied to develop the residential design. Verification that the limits have been satisfied require application of the 120/240V nomograph (Design Manual 5431) to determine cable sizing and to determine the transformer size in accordance with Design Standard 5621.

   a. When sizing cable for lots with air conditioning systems, always check secondary flicker (Design Standard 5413). Some systems are now flicker limited due to the higher voltage drop allowance.

   b. Eliminate all possible secondary handholes as described in Design Manual 5712.

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7. The purpose of this example is to show the process of designing an underground electric distribution system to serve a single-family residential subdivision. See Illustration in Design Manual 5222.4.

   a. From the 77 lot subdivision shown in Figure 2 below and the General Design Procedures, the following has been determined:

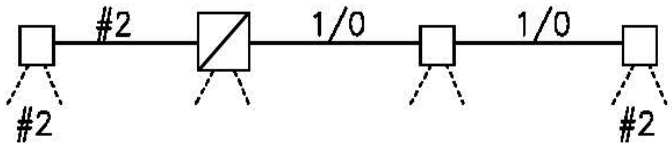
      KW Demand Category - 5KW electric water heating

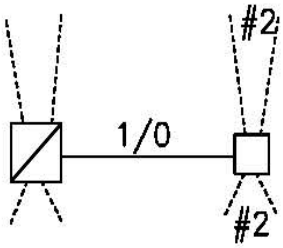
      Secondary Distance - 100' Typical (Including cable tails)

      Service Panel Setback - 40' Typical

      Long Service Distance - 90' Typical (Including cable tails)

      From the Optimum Array Table (Design Manual 5223.5 – 5223.8), the typical one-sided and double-sided arrays are shown below.





transformer size single–sided – 25kVA
double–sided – 25kVA

   b. By blocking the subdivision off by the number of customers which each array can serve, the result would be the configuration shown in Figure 2.

   c. To serve lots 20, 21, and 39 through 44, a combination array was used. Bu using this type of combination, many types of irregular lot configurations can be served.

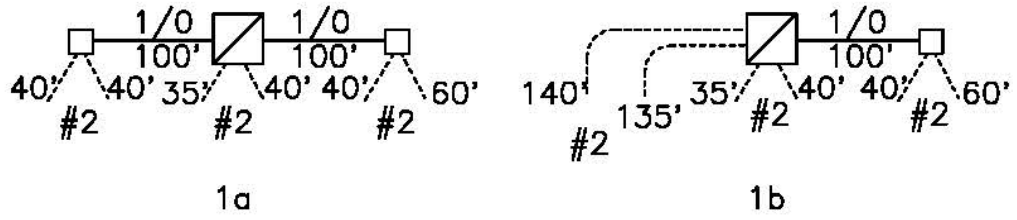
   d. From the handhole at lot 63-64, an additional service was used to serve lot 7. From the 120/240V nomograph, 3 @ 5 KW = 11.3 KW, the voltage drop for the 1/0 secondary was determined to be .68 percent and the addition of .63 percent voltage drop for the 150' #2 service brings the final voltage drop to 1.31 percent, below the 1.8 percent maximum limit. A check of the transformer loading reveals the final diversified demand, 9 @ 5 KW, to be 24.8 KW (27.6 KVA). A 25 KVA transformer was selected according to Design Manual 5621. However, because the transformer loading is 110 percent, the maximum permitted cable system voltage drop is 1.8 percent. REFERENCE: Table 1 – 5323.1, 5222.1, A.1, & 5431.1.

   e. An example of handhole elimination (Design Standard 5712) is shown for the array at lots 44 to 54. Figure 1A shows the original array configurations while Figure 1B shows the final configuration after the handhole, to the left of the transformer, was eliminated. The right side handhole may not be eliminated because doing so would result in 160' service.

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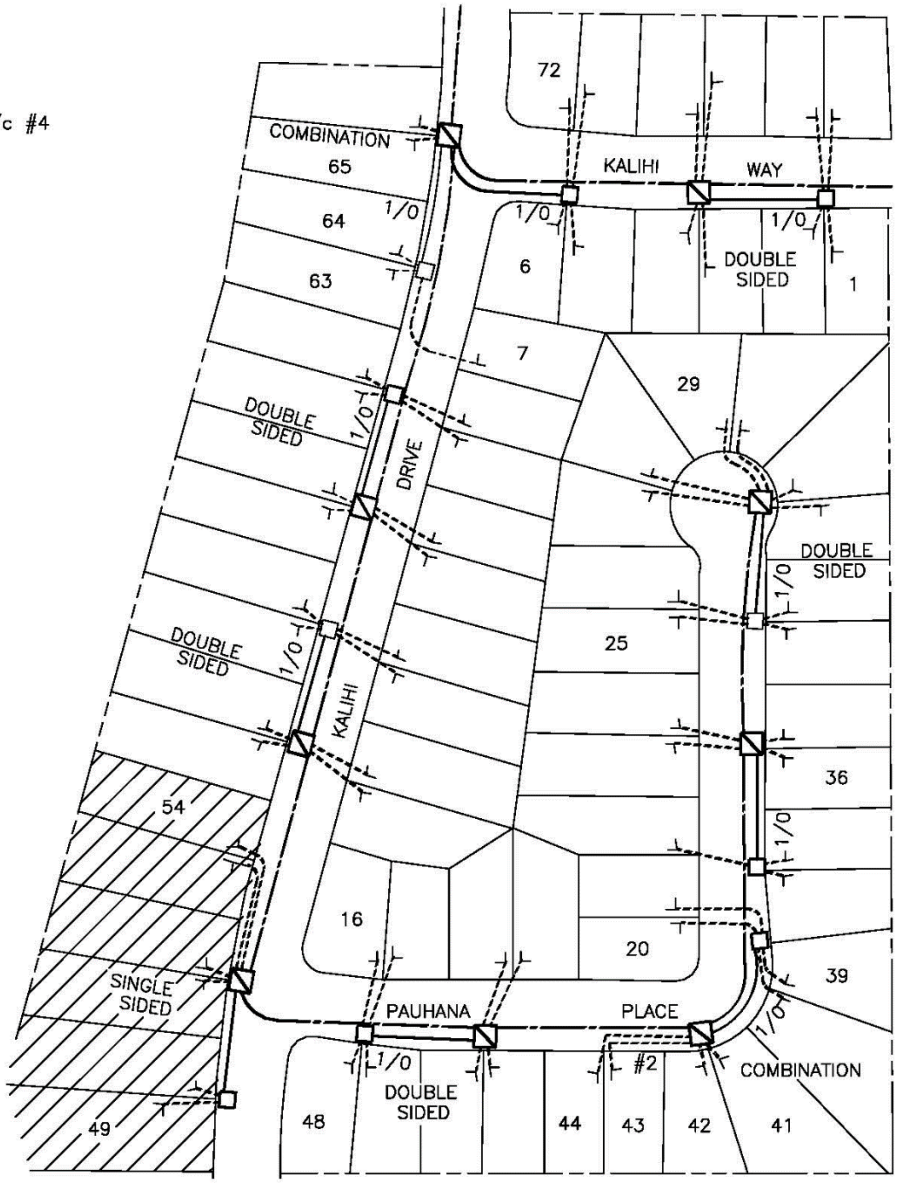
1a 1b

Figure 2: Subdivision used as a study vehicle in the example.

0 – 1299 SQ. FT.
200 amp board
5kW demand (per table 1, 5322.3)
Electric Water Heating

—·—·— Primary
——— Secondary
------- Service*

*All services are
2–1/c #2 & 1–1/c #4



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SCOPE

This design standard provides common infractions of state General Order 128 (G.O. 128) and the associated rules.

CRITERIA

A. Common Marking Infractions

1. Subsurface Equipment Not Marked

   a. Manholes, handholes, and subsurface equipment enclosures shall be marked as to ownership (Rule 17.8).

2. Missing Signs

   a. Warning signs indicating high voltage shall be installed (Rule 35.3):

      1) On an exterior surface or barrier, if present, inside the entrance of vaults, manholes, handholes, pad-mounted transformer compartments, and other above-ground enclosures containing exposed live parts above 750V.

      2) On an exterior surface of all such pad-mounted transformer compartments and other above-ground enclosures.

      3) So as to be clearly visible to a person in a position to open any such access door, another opening, or barrier.

3. Cables Not Clearly Identified

   a. Where there is more than one cable circuit in excess of 750V, the cables shall be permanently and clearly identified by tags or other suitable means to indicate their operating voltage and the circuit with which they are normally associated. This marking shall appear at each manhole or other commonly accessible location of the underground system (Rule 35.1).

B. Common Equipment Security & Protection Infractions

1. Enclosures Not Secure

   a. Compartments and enclosures shall be made secure against entry by unauthorized persons by the use of locks or other suitable means (Rule 34.3C).

2. Covers Not Bolted Down

   a. Manholes, handholes, and subsurface equipment enclosures, while not being worked in, shall be securely closed by covers and shall require a tool or appliance for opening (bolt down covers – Rule 32.7).

3. Possible Wire Entry

   a. Compartments and enclosures which will, during normal operation, contain exposed live parts shall be designed and installed to prevent a person from passing a wire or other conducting material into such compartments from the outside when it is closed (Rule 34.3B).

4. Equipment Not Secured in Place

   a. Pad-mounted equipment cases or enclosures shall be secured in place (Rule 34.3A).

5. Equipment Not Grounded

   a. Grounding is required on (Rule 36.5A):

      1) Transformer windings not exceeding 250V.

      2) Neutral conductors of 0-750V circuits.

      3) Neutral conductors of supply circuits above 750V (shall be grounded in manholes and at other locations where the conductors are accessible).

      4) Metal cases of transformers, switches, and other supply equipment.

      5) Above-ground metal enclosures in which supply conductors are terminated.

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C. General Infractions

1. Ducts Not Sealed

   a. Lateral ducts for service to buildings, through which water may enter buildings, shall be plugged or sealed (Rule 31.6).

2. Equipment Too Close to Buildings

   a. Equipment containing oil shall be so that the nearest metal parts of such equipment clear the surface of buildings by not less than 3ft. This clearance may be reduced to 2ft if the building surface is non-combustible (Rule 34.3D).

REFERENCES

I. General Order 128 - Rules for Construction of Underground Electric Supply and Communication Systems

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SCOPE

This design standard establishes preferred cable installation practices and shall be used by all designers/planners when designing underground jobs.

CRITERIA

A. General Primary Conductor Application

1. Cable size is to be determined based on expected loading.
   a. Single-phase lateral branches extending from a three-phase system should use at a minimum 1/C #2 aluminum cable.
   b. Three-phase loads should use 3–1/C–#2 or 3–1/C–#2/0 aluminum cable as required for ampacity. 350 kcmil, TRXLPECN–PEJ, 3–1/C aluminum cable can be used as a feeder cable where the largest available conduit is 4in and the projected load will not require the use of 750 compact cable.
   c. 1,000 kcmil, TRXLPECN–PEJ, 3–1/C aluminum cable should be used as feeder cable when a 5in conduit is available except in the substation getaway, see #4.
   d. 1,000 kcmil, TRXLPECN–PEJ, 3–1/C copper cable should be used in the substation getaway to the first substructure or cable pole outside the substation fence when a 5in conduit is available. Please consult EDP Engineer if the copper cable is required past the first structure.
   e. 750 kcmil, EAM–PEJ, compact aluminum and copper cable, may be used where the largest conduit available is 4in.
   f. For areas where existing PILC circuits are to be extended, splicing kits are available to transition from PILC to EAM. These transition kits must be ordered for each job (see UG4147). If space is available in the substructure, the N-Junction CLEER should be installed (see UG4198).

B. Special Use of 3–1/C–#2/0 Aluminum Cable

1. There are some cases when the load served is too large for a single fusing device but not large enough to need cable larger than 2/0 aluminum. In those cases, 2/0 cable may be used subject to the following criteria:
   a. All looping criteria must be met. This includes both feeder and local distribution (see DM5220 and DM5221).
   b. The 2/0 cable is the most practical cable to use, as determined by Synergi engineering analysis.
   c. The area to be served by 2/0 cable is "enclosed," i.e., no future development is possible except as allowed in (4) below.
   d. In some cases, 2/0 cable may be used to delay the installation of the more expensive larger cable. This may be done if the larger cable is not needed for at least ten (10) years.

C. Spare Conduits

1. Spare conduits should be considered or installed:
   a. All Primary conduits should be at a minimum of 3in.
   b. In all new feeder construction, a minimum of one spare conduit per circuit is required.
   c. When requested by a customer at his own expense, but not to exceed conduit limitations in this standard.
   d. Based on future construction limitations such as beneath bridges, roadways, and railroad tracks, but not to exceed conduit limitations in this standard.
   e. Specified by either the planner or distribution planning for future load growth.
   f. In conversion or new business projects – to allow easy bypass of the pole during removal. Conduits installed for this purpose shall not go up the pole but, rather, shall extend past the pole a minimum of 6ft.

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REFERENCES

I. Electric Distribution Design Manual 5220, Residential Primary System Design Normally Open Loop Systems

II. Electric Distribution Design Manual 5221, Commercial / Industrial Primary System Design Normally Open Loop Systems

III. Underground Construction Standard 4147, 750 Compact EAM to 500 PILC Splice

IV. Underground Construction Standard 4198, N-Junction CLEER 600A 25kV & Square CLEER 600A 25kV

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SCOPE

This design standard provides criteria for determining the proper electric distribution trench positioning and depth. This design guideline was developed to ensure trench standard utility location and soil stability during and after construction by maintaining adequate separation from foreign objects.

DEFINITIONS

- None

CRITERIA

A. Distribution Trench Positioning

1. Typical Utility Location in Street

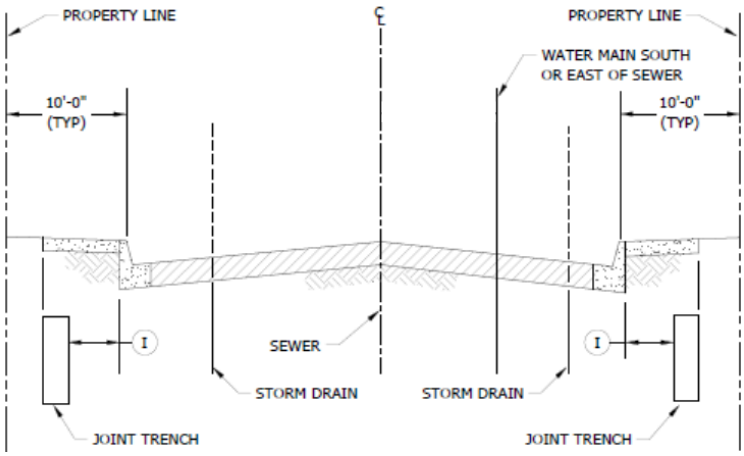


Figure 1

New Construction – Typical Street

Reference: UG3362 Utility Locations in Local and Collector Streets in S.D. County

2. Fire Hydrants

a. Fire hydrants are installed with a thrust block which is a large body of concrete that poses a difficult construction obstacle. When design permits, locate the underground system on the opposite side of the street from water lines and fire hydrants. When this cannot be accomplished, locate underground systems, as shown in Figures 2 and 3 below.

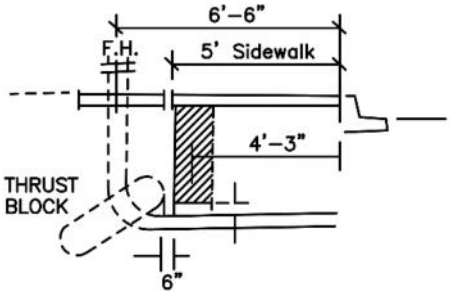


Figure 2

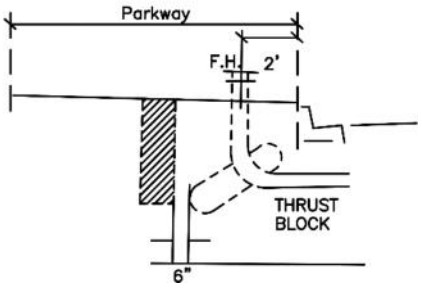


Figure 3

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b. Figure 2: Dimension the center line of the trench so that electric and gas positions fall under the back edge of the sidewalk. Electric conduit should not extend beyond the edge of the sidewalk, and a 6in minimum clearance from the fire hydrant thrust block shall be maintained.

c. Figure 3: If possible, the trench position should be located 3ft from the rear of the fire hydrant thrust block. If this cannot be done and a 6in minimum separation is used, it should be noted on the work order that the fire hydrant must be shut off by the water company prior to digging.

ATTENTION: The County of San Diego requires a 3ft separation between the fire hydrant and any above-ground obstacle, such as a piece of pad-mounted equipment.

3. Onsite Wastewater Treatment System (OWTS) Separation Requirement (Septic Leach Lines)

a. Figure 4: The San Diego County Health Services Department requires a 5:1 horizontal setback with 10 ft minimum separation from edge of homeowner OWTS to edge of utility trench (see Measurement "D" in Figure 4). It is SDG&E's policy to maintain this separation in San Diego and Orange Counties when placing a trench in the vicinity of existing septic tank, leach lines or seepage pits. (County of San Diego Dept of Environmental Health Land and Water Quality Division, Local Agency Management Program (Lamp) for Onsite Wastewater Treatment Systems, Feb. 24, 2015)

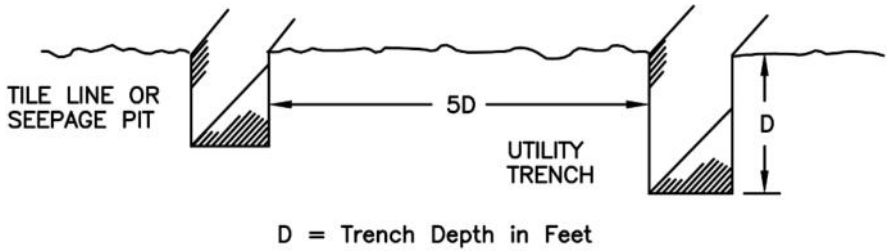


Figure 4

4. Trenches in Proximity to Buildings

a. Service conduit will only be allowed underneath the building being served by the cable. No conduit is allowed under one building to serve another building.

b. 1:1 Degree Rule: Any trench paralleling a building footing or structure and is deeper than the building or structure footing or any other foundation shall be based on the ratio of 1:1 (horizontal distance to depth) as shown in Figure 5.

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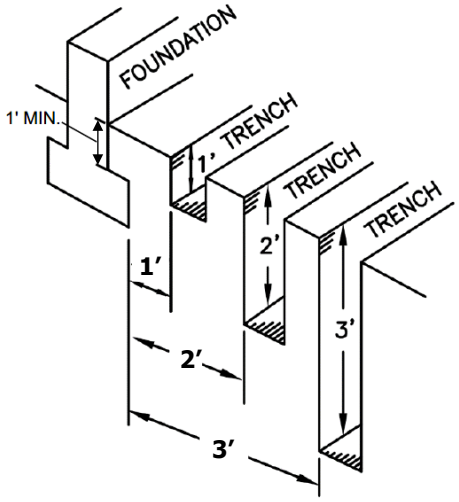


Figure 5

ATTENTION: The depth of a trench paralleling any foundation is limited by the distance from the foundation. For example, with a trench depth of 2ft, then measuring from the trench wall nearest to the foundation, the minimum distance from the trench wall to the foundation is 2ft.

EXCEPTION: This standard illustrates a service trench excavation paralleling a residential building. Trench length is limited to a maximum of 10ft. This is an acceptable exception to (1:1 ratio) provided all the installation requirements specified below are met (exception to the 1:1 rule in UG3367.1 and Gas Standard 7415.1).

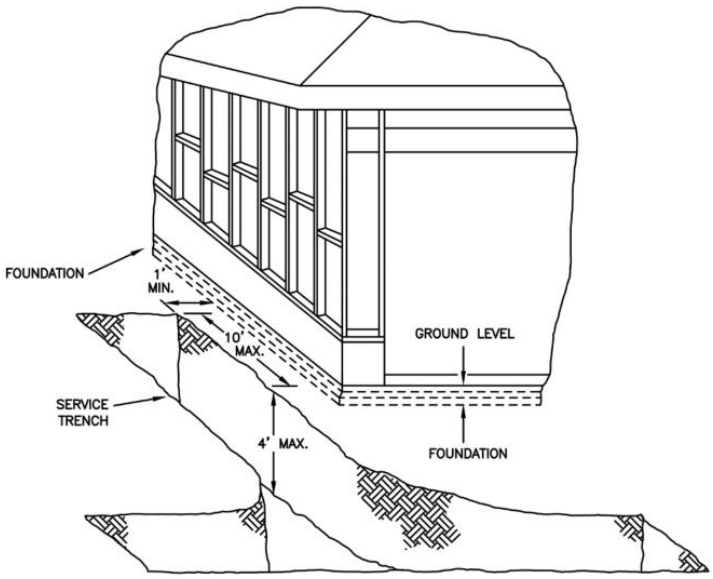


Figure 6

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INSTALLATION

A. The following conditions must be met:

1. Building has continuous concrete slab.
2. Building height is limited to two stories.
3. Trench must be a minimum of 1ft from the foundation, must not exceed a 10ft length along the foundation, and must not exceed a 4ft depth, as shown in Figure 6.
4. Soil conditions must be deemed stable by a geotechnical engineer and must not cause undermining of the foundation.
5. Trench walls must be stable before and after the excavation.

B. If the condition(s) in INSTALLATION: Item A cannot be met, then the 1:1 rule must be followed.

C. Distribution Trench Depths

1. See UG3370 or UG3371 to determine the trench depth required for individual applications dependent on applicable County jurisdiction.
2. Shoring
   a. All trenches 60in or deeper require shoring. If a project requires shoring, it must be reflected in the cost estimate as a cost for the party providing the trench. Any trench less than 60in where ground movement is suspected must be shored upon request of SDG&E's inspector.

D. Trench in Proximity to Wet Utilities and Underground Electric Transmission Lines

1. A minimum of 5ft centerline to centerline, with 3in of undisturbed soil, is the required separation between the SDG&E trench and wet utilities. See UG3370, Note J, and UG3371, Note H.
2. The following table shows the minimum separation, from trench "edge-to-edge" for various transmission voltages, between transmission and distribution trenches:

TABLE 1

TRANSMISSION VOLTAGE (KV)	SEPARATION TO DISTRIBUTION TRENCH (FT)
230	20
138	15
69	5

REFERENCES

I. Service Planning Manual 282, Trenching Near Existing Gas and/or Electric Distribution Facilities

II. Service Planning Manual 360, Gas Meter Locations, Service Extensions, and Barriers

III. Service Planning Manual 487, Trench Inspection Procedures

IV. Underground Construction Standard 3367, Trench Paralleling Foundations

V. Underground Construction Standard 3370, Underground Distribution (UD) Trenches and Utility Positioning – S.D. County

VI. Underground Construction Standard 3371, Underground Distribution (UD) Trenches and Utility Positioning – Orange County

VII. California Building Code, Chapter 18, Soils and Foundations

VIII. California Code of Regulations, Title 8, Subchapter4, Article 6, Sections 1540, 1541, and 1541.1

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SCOPE

This design standard establishes the cable tail length required to locate and terminate underground cable in equipment or on cable poles. This design standard provides the necessary additional cable footage (cable tail length) to the total cable requirements.

DEFINITIONS

- Lateral Distance – The horizontal separation (L) between points of cable entry into underground equipment. This is normally represented as the trench length between adjacent pieces of equipment.
- Cable Tail Length – The additional cable footage required beyond the lateral distance to allow for the trench depth (D) and cable termination (T). (e.g. Tail Length = D + T)

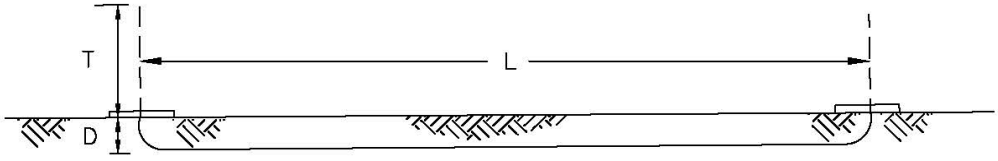


Figure 1

Cable Definitions

CRITERIA

The following illustrations show standard cable tail lengths for a variety of design configurations:

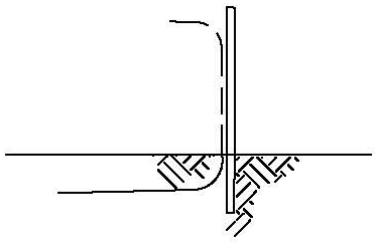
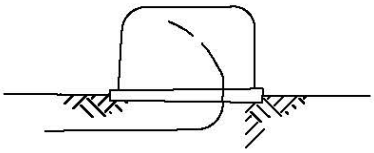
	Illustrations	Cable Tail Lengths
A. Cables Poles		
For primary cable For secondary cable		Calculation of cable tail lengths for cable poles is based on the measurement from the ground line to the top of the conduit plus 8ft of cable.
B. Padmounts		
Single-phase terminator (UG3522)		6ft

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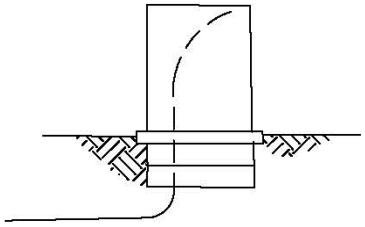
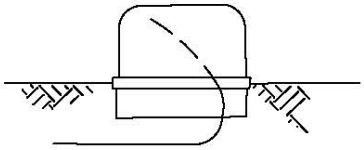
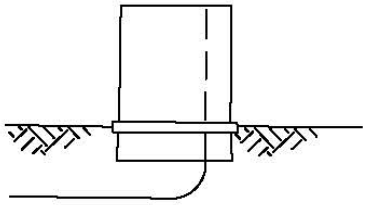
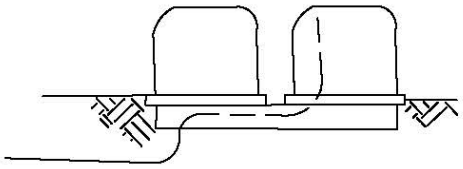
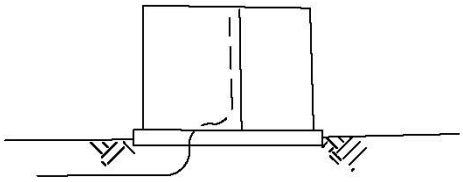
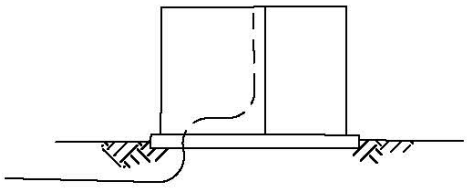
	Illustrations	Cable Tail Lengths
With three-phase terminator, existing (UG3517 through UG3524)		8ft
With single-phase fuse cabinet (UG3512)		6ft
With three-phase fuse cabinet (UG3514 & UG3515)		8ft
With single-phase deadfront, open-delta transformer with handhole (UG3713)		11ft
With three-phase deadfront transformer (UG3751)		7ft
With three-phase livefront transformer (3,000 kVA) (UG3702.5)		13ft

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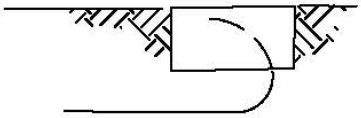
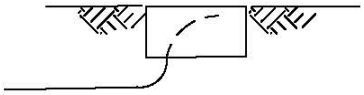
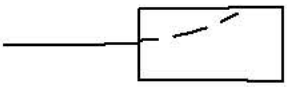
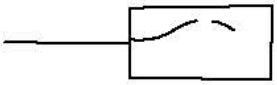
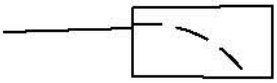
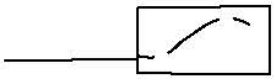
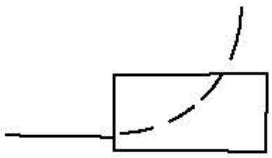
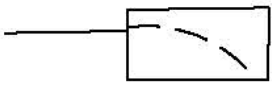
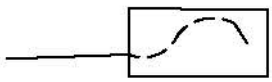
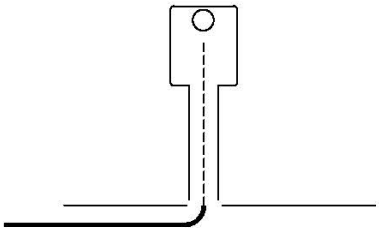
	Illustrations	Cable Tail Lengths
C. Handholes		
(UG3309.1 & UG3312)		6ft
(UG3309.2 & UG3313)		7ft
(UG3314)		8ft
(UG3314) with cable taps		9ft
(UG3315)		8ft
(UG3315) with cable taps		10ft
(UG3315 or 3316) with padmounted switch		13ft
(UG3316)		13ft
(UG3316) with cable taps		16ft
E. Meter Panels (SG500)		10ft

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

CABLE TAIL LENGTH REQUIREMENTS

REFERENCES

I. Underground Construction Standards Section 3300

II. Underground Construction Standards Section 3500

III. Underground Construction Standards Section 3700

IV. Service Standards & Guide Section 500

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SCOPE

This design standard provides criteria for locating padmounted electrical equipment near all street intersections in order to provide crossing and merging vehicles with an unobstructed view of oncoming traffic. it also applies to driveways in shopping centers, commercial/industrial areas, and residential areas.

DEFINITIONS

- Sight Distance – The distance along a roadway that an object of 4.5ft in height is continuously visible to a driver on a cross street. This distance is determined by the height of the driver's eye above the road surface, assumed to be 3.5ft, and the speed of oncoming traffic.

CRITERIA

A. At all street intersections, padmounted equipment shall not be located within the area between the sight distance line and the street (see "Exceptions" below). This area is indicated by the hatched area shown in Figures 1 and 2. This sight distance line is measured between Points A and B as shown in the figures:

   1. The distance between Points A and B is equal to eleven (11) times the design speed limit of the through street. Example: For a speed limit of 35 MPH, the distance between Points A and B is 385ft.
   2. Point A is 3.5ft (42in) above the road and is located 3ft to the right of center on the cross street and 15ft back from the curb face line or edge of pavement of the through street (see Detail A).
   3. Point B is 4.25ft (51in) above the road and is located 6ft to the right of the left edge of the near lane (see Detail B).

B. If possible, padmount equipment should not be located within 100ft of any intersection as measured from the nearest point of curb return (PCR), see Figure 3.

C. An effort should first be made to place the padmount equipment on the right side of the intersection because this will eliminate most conflicts. If the padmount equipment is placed at the right of the intersection, a line-of-sight review is still required.

D. These criteria also apply to street intersections that do not meet at 90 degrees, as shown in Figure 2.

EXCEPTIONS

A. Poles and streetlights may be located within sight distance.

B. Facilities may be located between the sight distance line and the street, provided they are completely under the sight distance line. In most cases, where the topography is level, a single-phase transformer and pad and a three-phase transformer and pad are less than 4in high and will meet these criteria, so a line-of-sight calculation is not required. However, care must be used to determine this for each case. If the through road is lower than elevation, then a calculation is required.

C. If the through road is higher in elevation to the left of the cross street, then padmounted equipment may be located in the hatched area, provided the sight distance line is higher than the installed height of the equipment. This must be determined by calculation.

D. If the through road is a one-way street, the line of sight distance only applies to the direction where the traffic is approaching the cross street, see Figure 4.

E. If the intersection is a standard 3 or 4-way stop intersection, the line of sight distance does not apply, see Figure 5.

F. If the intersection is fully controlled, the line of sight criteria is not applicable.

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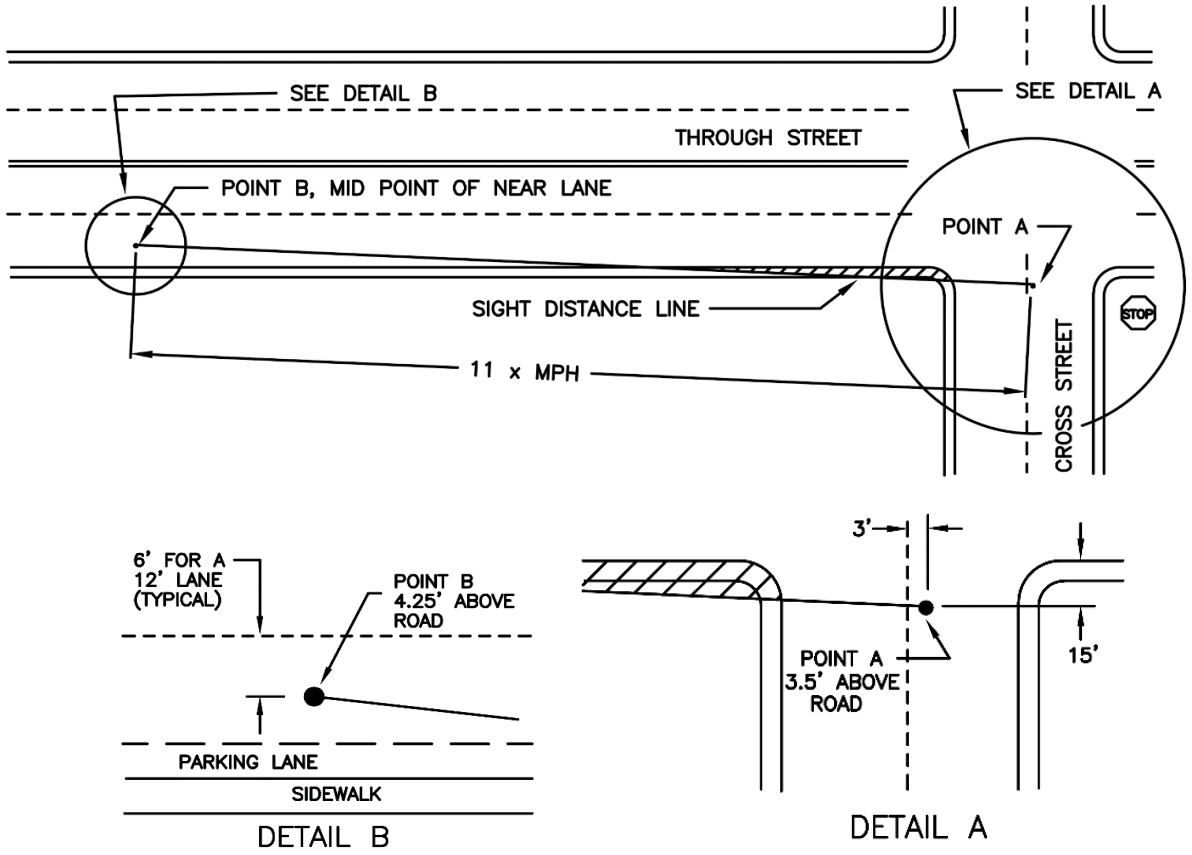


Figure 1

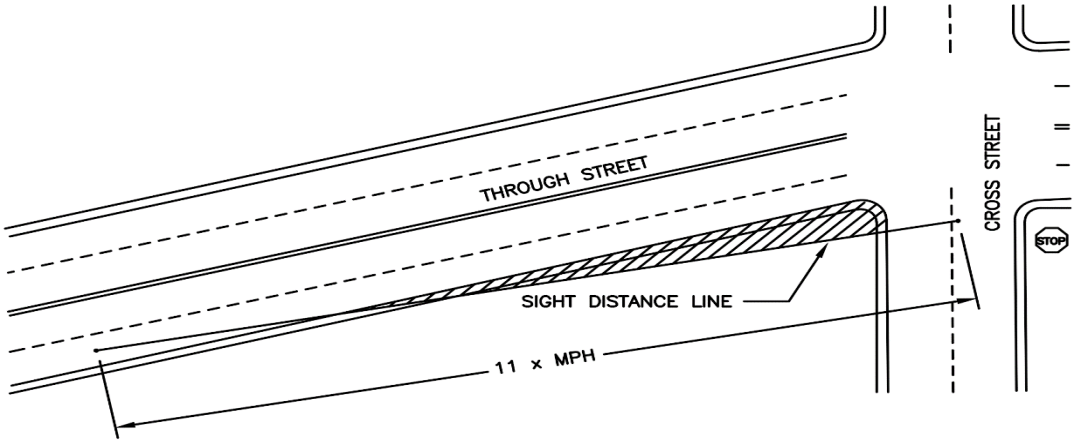


Figure 2

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SIGHT DISTANCE REQUIREMENTS

DM5236.2

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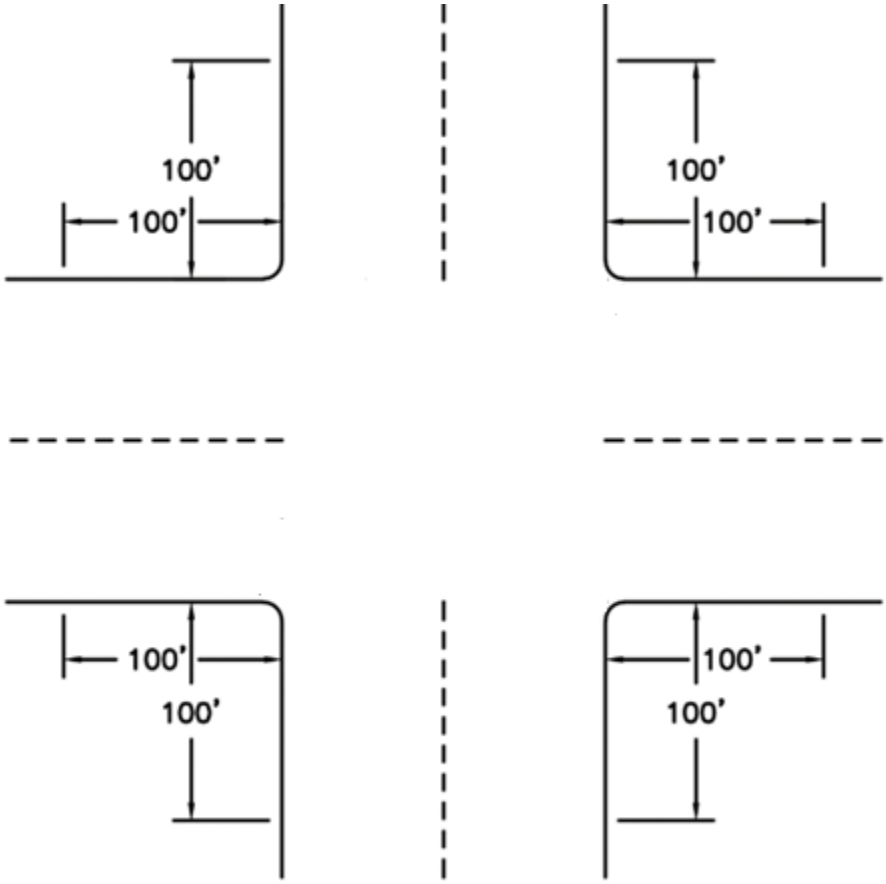


Figure 3

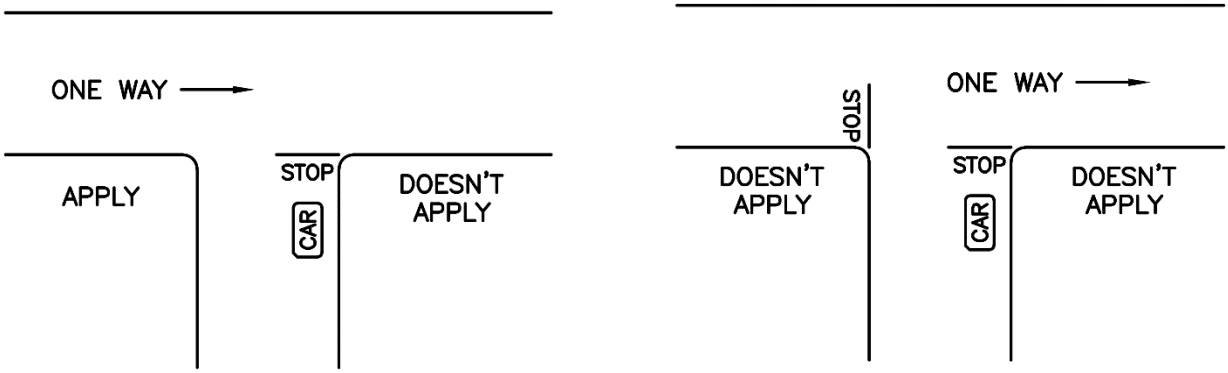


Figure 4

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SIGHT DISTANCE REQUIREMENTS

DM5236.3

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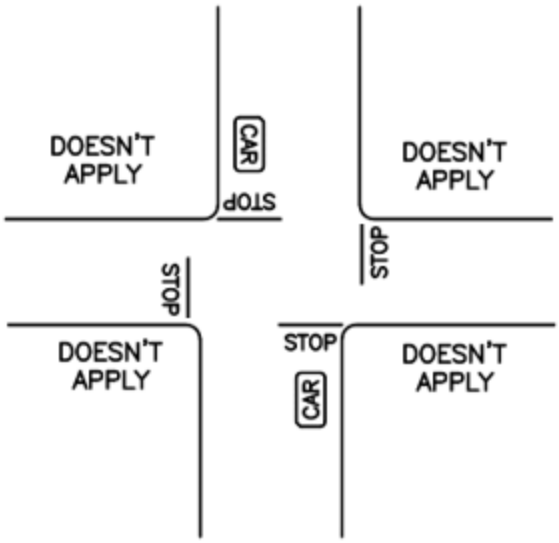


Figure 5

REFERENCES

I. None

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SCOPE

This design standard provides criteria for selecting between padmounted and subsurface equipment for the underground distribution system. This design standard also provides criteria for locating padmounted equipment in the public right-of-way.

GENERAL CONSIDERATIONS

A. Padmounted equipment is standard for all applications on the electric distribution system. New loads connected to the underground system are to be served with padmounted transformers. Except for single-family residential applications, transformers are to be located on the customer's property or inside the customer's building in a dry vault.

B. Some of the reasons for the padmounted standard are listed below:

1. Customer service interruptions are longer when failures occur in subsurface systems. In general, a crew is required to operate subsurface switches because of difficult access and the frequent need to pump water from substructures before restoration procedures can begin. Padmounted equipment, on the other hand, can generally be operated by a single troubleshooter.

2. Transformers, switches, and other equipment installed in subsurface environments are exposed to groundwater seepage, high humidity, and corrosive runoff (fertilizers). These factors lead to accelerated equipment deterioration and increased maintenance. Subsurface equipment will experience higher failure rates than is expected for padmounted equipment due to the hostile subsurface environment.

3. Subsurface systems are more expensive than padmounted systems. Initial installation costs and continuing maintenance costs for the subsurface system combine to produce a higher overall cost.

CRITERIA FOR SELECTING BETWEEN PADMOUNTED AND SUBSURFACE EQUIPMENT

A. Pad-mounted equipment is to be used for all underground distribution applications. Subsurface equipment is only allowed if it meets the criteria in sections 'B' and 'C' below along with an approved Deviation Request by EDE. Subsurface equipment may be installed in urban and/or redevelopment areas where the general criteria for locating padmounted equipment cannot be met due to insufficient right-of-way to accommodate padmounted equipment and/or maintain all the required operating clearances outlined in UG3483, Minimum Operating Clearance Requirements for Padmounted and Subsurface Equipment.

B. Subsurface equipment may be installed when the only available padmounted location would put the equipment at unusual risk including vehicle contact.

C. A subsurface switch should be installed if all of the following conditions apply:

1. Deviation Request is approved by EDE.

2. Existing Substructure - There is an existing substructure that will accommodate the switch, and the substructure does not have a significant water or corrosion problem.

   a. Subsurface switches that are labeled 'Do not Operate Energized' (DOE) should be replaced in-kind at a minimum. However, if SCADA is justifiable, please reach out to the district engineers and/or Electric Distribution Planning (EDP) for guidance.

3. Traffic Control - The operation or maintenance of the switch will **NOT** create excessive traffic congestion or excessive traffic control requirements. Rule of thumb – not allowed in high-traffic areas.

4. Cost Differential - The installed cost of the padmounted switch exceeds the installed cost of the subsurface switch by 50% or more.

   a. Example, if the installed cost of a subsurface switch is estimated to be $400k, and the installed cost of the padmounted switch is estimated to be $650k (i.e. exceeds by 63%), then an Deviation Request should be submitted to EDE for final consideration to proceed with the subsurface switch installation.

   b. Example, if the installed cost of a subsurface switch is estimated to be $400k, and the installed cost of the padmounted switch is estimated to be $550k (i.e. exceeds by 38%), then the pad-mounted switch design should be constructed.

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5. The following list of equipment may be installed subsurface if the criteria of this standard are met:
    a. 120/240V single-phase transformer stations
    b. 240/120V and 208Y/120V three-phase transformer stations
    c. Three-phase fuse cabinets
    d. Multi-way 600A switches
    e. ON-OFF switch

CRITERIA FOR LOCATING PADMOUNTED EQUIPMENT IN PUBLIC RIGHT-OF-WAY

A. The overall width of the area between the face of the curb, berm, or edge of the roadway and the property line must be large enough to accommodate the equipment and provide required SDG&E clearances. When sidewalks are present, a minimum of 48in for wheelchair clearance must be provided. Wheelchair clearance can be defined as a pedestrian traffic area where wheelchairs can travel within a 48in wide path, excluding curb, unobstructed by above-ground facilities/equipment. See Figures 1 & 2.

B. The position of padmounted equipment must meet the operating clearances and the barrier & protection clearances shown in the UG3481, Minimum Operating Clearance Requirements for Padmounted Equipment and UG3483, Minimum Operating Clearance Requirements for Padmounted and Subsurface Equipment. Clearances may be reduced but only after approval of a deviation request, which should be processed during the design phase and prior to the job issue.

C. Padmounted equipment must not interfere with the sight distance requirements of DM5236, Sight Distance Requirements.

D. The preferred location for padmounted equipment is behind the sidewalk, 5ft from driven roadways, as shown in Figure 2. However, if this is not practical, equipment may be set using traffic barriers, as shown in Figure 1.

E. Transformers installed should also comply with noise criteria in DM5612, Transformer Noise Criteria.

F. The aesthetics of the installation must be considered. The following lists some considerations which should be taken into account:

1. Facilities should be placed to present as neat an appearance as possible. It is generally better to group equipment together rather than randomly string green boxes along a sidewalk. However, avoid grouping so many padmounted cabinets that a cluttered appearance is created.
2. Avoid setting padmounted equipment on sidewalks that have a very heavy flow of pedestrian traffic, such as the more congested areas downtown.
3. Avoid setting any equipment that would have the appearance of blocking the entrance to any building or the appearance of a pedestrian traffic obstruction.
4. When padmounted equipment is set on sidewalks, it should be set back from the intersection far enough to avoid "surprising" pedestrians or bicycle riders when they turn the corner.

G. If these requirements cannot be met, then subsurface equipment should be considered. The design should address safety, the integrity of the distribution system, and aesthetics.

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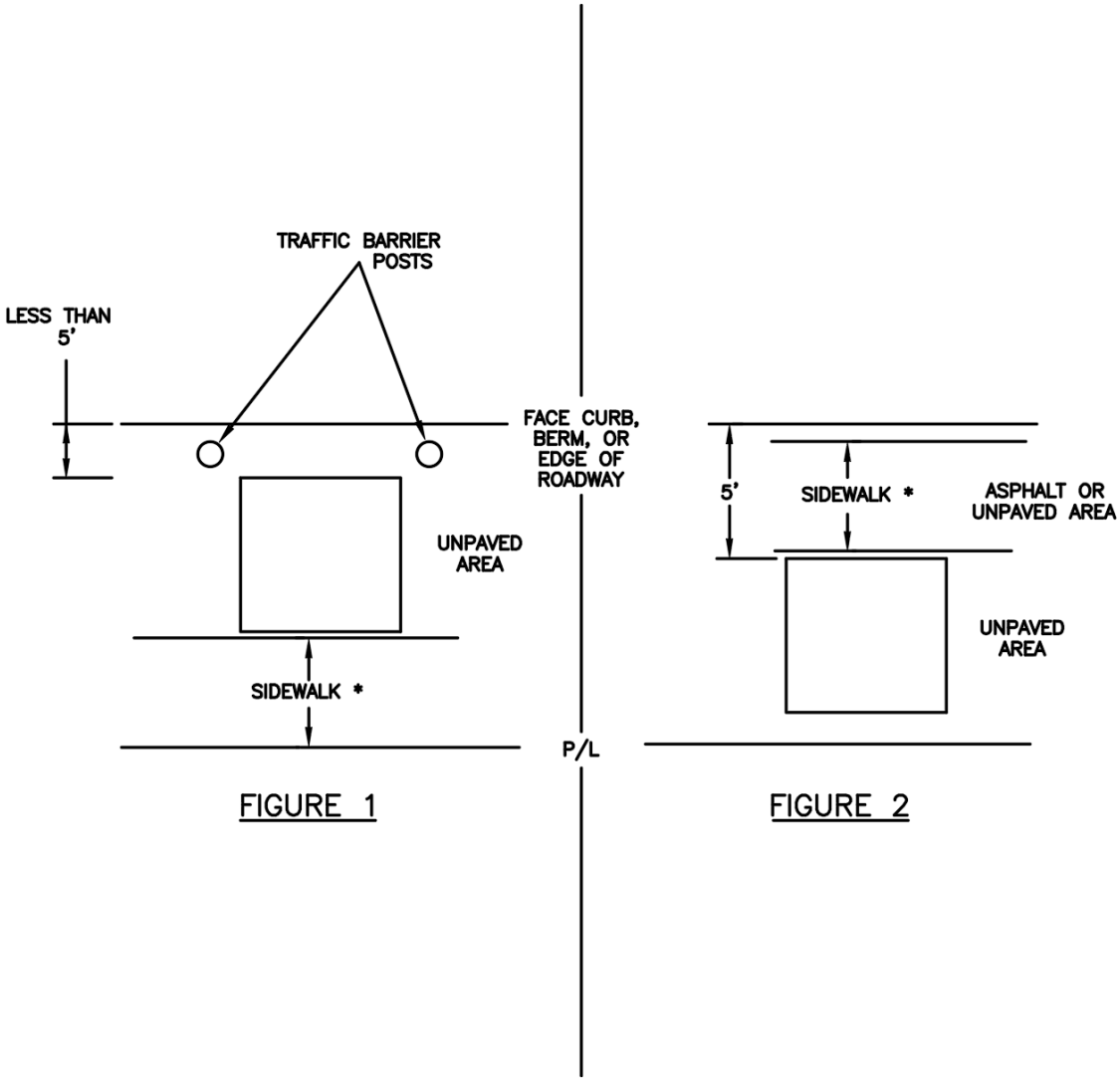


FIGURE 1

FIGURE 2

* MINIMUM 48" CLEAR SIDEWALK AREA, EXCLUDING CURB, REQUIRED FOR WHEELCHAIR CLEARANCE.

REFERENCES

I. Design Manual 5612, Transformer Noise Criteria

II. Design Manual 5236, Sight Distance Requirements

III. Underground Construction Standard 3481, Minimum Operating Clearance Requirements for Padmounted Equipment

IV. Underground Construction Standard 3483, Minimum Operating Clearance Requirements for Padmounted and Subsurface Equipment

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SCOPE

This design standard provides descriptions, common applications, functions, and configurations guidelines for underground sectionalizing equipment. These guidelines are established to promote consistency and uniformity when designing feeder extensions and to standardize the types of equipment used to sectionalize the UG distribution system.

EQUIPMENT DESCRIPTIONS

A. Innovative Switchgear (ISG)

These switches have 304 stainless steel tanks, solid di-electric insulating mediums, fault interrupting, and fault closing capable vacuum interrupters. Each position can be grounded individually. Viewing windows are included to visually verify operational status (Open and Closed).

These switches are stocked in many configurations for use on padmount, submersible, vault-mount, and wall-mount for 12 kV and 4kV applications. Due to various applications, there are also 600A and 200A connections depending on which specific unit is chosen.

All manual ISG Switches are SCADA-ready and can be retrofitted for SCADA integration by adding a SCADA control cabinet. (refer to ESP210).

Common Applications:

1. Feeder Protection
2. Midpoint SCADA and SCADA Ties
3. Protection for transformers (refer to Table 1, DM6111)
4. Feeder Ties
5. Can be used for branching and furcating
6. Source-transfer functionality

B. Trayer Switch

These switches have 304 stainless steel tanks, oil insulating mediums, fault interrupting, and fault closing capable vacuum interrupters. Each position can be grounded individually. Viewing windows are included to visually verify operational status (Open, Closed, and in some applications, Grounded).

These switches are stocked in many configurations for use on padmount, submersible, and vault-mount for 12 kV applications. These switches are only available with 600A connections.

Common Applications:

1. Feeder Protection
2. Midpoint SCADA and SCADA Ties
3. Protection for transformers (refer to Table 1, DM6111)
4. Feeder Ties
5. Can be used for branching and furcating
6. Source-transfer functionality
7. Microgrids only, use the Trayer High-Speed Close-Coil (HSCC) version (S704738) designed to close within 3-cycles and maintain reliability (refer to UG4720).

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C. S&C PME-Switch/Fuse Cabinet

These switches are air-insulated, double-sided, padmounted cabinet providing 600A or 200A three-phase gang-operated switches and/or three-phase fusing with a common bus. Switch compartments are loadbreak capable up to the continuous current rating on the nameplate.

Common Applications:

1. Fusing loads
2. Protection for transformers (refer to Table 1, DM6111)
3. Non-SCADA feeder Ties
4. Can be used for branching and furcating

D. Elastimold Molded Vacuum Switch (MVS) and Interrupter (MVI)

MVS: Molded Vacuum Switch – A single phase or three-phase solid dielectric vacuum switch capable of making, carrying, and breaking load up to 200A at 15.5 kV. The switch is insulated in EPDM rubber.

MVI: Molded Vacuum Interrupter – A single phase or three-phase solid dielectric vacuum switch capable of making and carrying load current up to 200A or 600A (depending on which specific unit is chosen) at 15.5 kV, and automatically interrupting fault current up to 12.5 kA. Fault closing is also permitted. These units are self-powered and include current sensing and electronic controls to provide over-current protection. The vacuum interrupter is insulated in EPDM rubber.

Common Applications:

1. Provides an alternative to installing a fuse cabinet, offering higher fault interrupting capability and load capacity.
2. Feeder Protection
3. Protection for transformers (refer to Table 1, DM6111)

NOTE: MVI's shall not be installed upstream of a circuit tie or 'normally-open' point. If a circuit tie or normally-open point is added at a later time, protection on the MVI shall be disabled.

E. Fuse Cabinet with Provisions for Feed-Through

This is a three-phase padmounted fuse cabinet with provisions for feed-through on the line and load side. Connections are made with 200A loadbreak elbows.

Common Applications:

1. Provides an alternative to installing a second fuse cabinet or 200A dead front terminators. Precaution should be taken not to overload the 200A loadbreak elbows of feed-through bushings.

F. Fused Elbow

This is a loadbreak elbow with a replaceable current-limiting fuse (30A), see UG4191.

Common Applications:

1. Fusing small loads

G. Handhole and 600A Dead Front Terminator

TEEs are used to splice feeder cable and may be used as tapping points for the local distribution system. When installed in handholes, TEEs are mounted at an angle so one end is accessible for attaching 200A loadbreak elbows. Where possible, install TEEs with the use of CLEER connector to increase operational flexibility (see UG3518, UG3646, UG3649, & UG4198).

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Whenever a Live Front Terminator is being touched as part of a job, it is recommended to replace with a Dead Front Terminator as shown in UG3517 or UG3518.

Common Applications:

1. Splice feeder cable and tap to local distribution – TEEs are a low-cost method of tapping underground feeders when there is no need for feeder sectionalizing.

H. Cam Link

Underground device providing the ability to quickly isolate underground feeder segments. Operable by a single Electric Troubleshooter, the cam-link is a molded connector assembly including a removable, current carrying part that can be replaced with a non-current carrying counterpart. Shall be operated only after both sides are tested de-energized. Can be installed within a 600A 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 (see UG4187).

I. CLEER Connector

This device is a 600A loadbreak connector. It is used to provide a visible break and visible ground on 600A network and distribution systems without having to remove 600A terminations and move heavy cable. Even though this device is loadbreak, SDG&E standard practice is to operate it de-energized (see UG4198, & UG4360).

NOTE: CLEERs should be installed every other structure, as space permits.

UG SECTIONALIZIG EQUIPMENT CONFIGURATIONS

NOTE: For more information about switch configurations, availability, and replacement, please refer to the UG Switch Replacement Matrix.

A. Padmounted equipment would include the following:

1. ISG Vacuum Switches with Fault Interruption Capability Available Configurations:
   a. In/Out Single-Sided: Available in 12 kV, 200A, and 600A, manual, and SCADA configurations (4 kV version available only with 600A SCADA configuration).
   b. In/Out Double-Sided: Available in 12 kV, 600A, manual, and SCADA configurations (200A availbabe only in manual configuration and 4 kV version available only with 600A SCADA configuration).
   c. 4-Way Single-Sided: Available in 12 kV, 600A, manual, and SCADA configurations (4 kV version available only with 600A SCADA configuration).
   d. 4-Way Double-Sided: Available in 12 kV, 600A, manual, and SCADA configurations (4 kV version available only with 600A SCADA configuration).
   e. 5-Way and 6-Way Single-Sided: Available in 4 kV, 12 kV, 600A, and SCADA configuration only.
2. Trayer Vacuum Switches with Fault Interruption Capability Available Configurations:
   a. 4-Way Single-Sided: Available in 12 kV, 600A, manual, and SCADA configurations.
   b. 4-Way Double-Sided: Available in 12 kV, 600A, and SCADA configuration only.
   c. 5-Way Single-Sided: Available in 12 kV, 600A, and SCADA configuration only.
   d. 4-Way High-Speed Close-Coil Switch (HSCC) for DER Interconnection: Available in 12 kV, 600A, and SCADA configuration only.
3. S&C PME Air-break Switches Available Configurations:

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C	Typo	JIK	MAK	-	-	09/19/2025	F						
B	DM Major Revisions	YZZ	AMK	FRC	KRG	01/03/2025	E						
A	Revision	--	--	--	MJC	01/01/2000	D						

a. PME-3 (In/Out) Double-Sided: Available in 12 kV, 600A, and manual configuration only.

b. PME-5 Double-Sided: Available in 12 kV, consists of a 200A switch compartment (one) and 200A fused compartment (two).

c. PME-9 Double-Sided: Available in 12 kV, consists of two 600A switch compartments (one & two) and two 200A fused compartments (three & four).

d. PME-10 Double-Sided: Available in 12 kV, consists of four 600A switch compartments.

e. PME-11 Double-Sided: Available in 12 kV, consists of three 600A switch compartments (one, two & four) and one 200A fused compartment (three).

4. MVS/MVI:

a. MVS Single-Phase: Available in 12 kV, 200A configuration (Not Fault Interrupting).

b. MVS Three-Phase: Available in 12 kV, 200A and 600/200A configurations (Not Fault Interrupting).

c. MVI Single-Phase: Available in 12 kV, 200A configuration (Fault Interrupting).

d. MVI Three-Phase: Available in 12 kV, 200A, 600/200A, and 600A configurations (Fault Interrupting).

5. Fusing

a. Fuse Cabinet, In/Out (Two-Way) Single-Sided 200A Fuse Configuration – Bushings for connecting are on one side and the fuses are located on the opposite side of cabinet.

B. Submersible equipment would include the following:

1. ISG Vacuum Switches with Fault Interruption Capability Available Configurations:

a. In/Out and 3-Way: Available in 12 kV, 600A, and manual configuration only.

b. 4-Way: Available in 12 kV, 600, manual, and SCADA configurations.

2. Trayer Vacuum Switches with Fault Interruption Capability Available Configurations:

a. 3-Way: Available in 12 kV, 600A, and manual configuration only.

C. Vault-mounted equipment would include the following:

NOTE: Submersible switchgear can generally also be installed in vault structures.

1. ISG Vacuum Switches with Fault Interruption Capability Available Configurations:

a. 4-Way: Available in 12 kV, 600A, manual, and SCADA configurations.

b. 5-Way and 6-Way: Available in 12 kV, 600A, and SCADA configuration only.

2. Trayer Vacuum Switches with Fault Interruption Capability Available Configurations:

a. 4-Way: Available in 12 kV, 600A, manual, and SCADA configurations.

b. 5-Way and 6-Way: Available in 12 kV, 600A, and SCADA configuration only.

D. Wall-mount equipment would include the following:

1. ISG Vacuum Switchgear Available Configurations:

a. In/Out: Available in 12 kV, 200A, 600A, and manual configuration only.

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2. MVS/MVI:

   a. MVS Single-Phase: Available in 12 kV, and 200A configuration (Not Fault Interrupting).

   b. MVS Three-Phase: Available in 12 kV, 200A, and 600/200A configurations (Not Fault Interrupting).

   c. MVI Single-Phase: Available in 12 kV, and 200A configuration (Fault Interrupting).

   d. MVI Three-Phase: Available in 12 kV, 200A, 600/200A, and 600A configurations (Fault Interrupting).

E. Utilized in all Underground Sectionalizing Applications:

   a. Fused Elbow

   b. Dead Front Terminator

   c. Cam Link

   d. CLEER

UG SECTIONALIZIG EQUIPMENT SPECIAL FUCTIONALITIES

A. Source Transfer Switch Functionality - Also known as an auto-transfer switch: Available in Multi-way ISG and Multi-way Trayer switches with SEL 487E Relay. The Source-Transfer functionality provides 600A group operated switches coupled to a special high-speed operating mechanism. This mechanism is controlled by a microprocessor device that senses loss of device and senses loss of potential from either source. Upon a sensed loss of potential, the device will initiate an "open" command on one switch position, followed by a "close" command on the other. Timing parameters are variable and are a function of settings at the feeder breaker(s), service restorer(s), or other devices/factors. Settings for the microprocessor controller are determined by System Protection.

   This function is used in special situations when alternate service is to be provided automatically. Typically used when a "special facilities" agreement is established, with a major customer, for alternate service. The alternate circuit should originate from a substation different from the preferred, or at least from a different bus at the same substation.

   This function is developed to provide customers with two source positions (preferred and alternate). Generally configured for a three or ten cycle interface to provide instantaneously consistent power to requested customers.

   Way 1 and Way 3 of the switch shall be assigned as the preferred and alternate feeds respectively.

   NOTE: Long lead time, special order item. Contact EDE at least six months in advance of the scheduled in-service date, to ensure timely arrival and to confirm exact switch configuration.

   NOTE: In the event of a fault downstream of any position of the switch (other than positions 1 and 3), if an upstream device trips, the Source Transfer function will not operate.

B. Trayer High-Speed Close-Coil Switch (HSCC) for DER Interconnection - This vacuum-insulated switch is used specifically for DER interconnection projects where SDGE is tying into a generation customer (i.e. microgrids). This switch has a designated switch position (Way 3) with a high-speed coil that is pre-charged and actuated closed which allows frequency synchronization of the interconnection customer's generation onto the SDG&E electric system (refer to UG4720).

REFERENCES

I. Underground Construction Standards

II. Electric Standard Practices 210, Innovative Switchgear Solution UG Distribution Switchgear

III. Electric Distribution Design Manual 6111, Feeder Circuit Sectionalizing and Protection

IV. UG Switch Replacement Matrix

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C	Typo	JIK	MAK	-	-	09/19/2025	F						
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C	DM Major Revision	QTC	KNM	FRC	KRG	12/13/2024	F						
B	Formatting	-	JIK	-	-	02/21/2020	E						
A	Original Issue	-	-	CVN	RDG	01/01/1990	D	Editorial	JIK	KNM	FRC	KRG	02/21/25

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SCOPE

This standard establishes the criteria for estimating commercial & industrial customer loads based upon Square Foot Demand and Load Schedule Demand.

PURPOSE

This criteria provides a standard method for estimating new commercial customer demands for sizing distribution transformers and secondary/service cables.

DEFINITIONS

Square Foot Demand – the estimated demand in kilowatts/square foot based upon building area and customer type.

Load Schedule Demand – the estimated demand based on the sum of the diversified loads, identified individually.

Future Load – connected load that is not installed by the building/project in–service date.

Estimated Demand Selection – the chosen demand estimate based upon Square Foot Demand or Load Schedule Demand.

Commercial Diversity Factor – the factor that is applied to the sum of the individual (customer) service point demands connected to any three–phase equipment or system.

Minimum Transformer Size – The smallest size transformer that will serve the initial peak load.

Ultimate Transformer Size – The size transformer that is needed to serve the ultimate (future) load of a building/project.

DEMAND ESTIMATING WORKSHEET APPLICATION

The following example demonstrates the proper use of the Demand Estimating Worksheet shown on page 5311.6.

EXAMPLE

The following equipment data has been provided from the Energy Load Information Agreement Form:

Given: A 22,400 square foot bank having a 120/208V service with a 1,000A service panel.

The transformer pad is 100 feet from the service panel. Total Air Conditioning load is 110.6 kW; the sum of two units.

STEP 1

Indicate the following on Demand Estimating Worksheet:
- Work Order Number
- DPSS Number
- Job Location
- Job Name

STEP 2

Building/Service Information:
- Transfer building/service information from the Energy Load Information Agreement Form to the Demand Estimating Worksheet:

- Building/service point number	1
- Building area	22,400 sq.ft.
- Serving voltage	120/208 Volts
- Service panel size	1,000 Amps
- Transformer to service panel distance	100 Ft.
- Largest motor size	25 HP (A/C Compressor)

Note:
It is necessary to identify the service point for each building by a number designation because larger buildings may be granted multiple service points.

STEP 3

Square Foot Demand Calculation: (Method one)
- Check box on Demand Estimating Worksheet by appropriate customer class to be calculated. (Refer to Table 1 on Page 5311.4).
- Multiply building area from Building/Service Information by the customer class (kW/sq.ft.) factor.
  - Customer Class — Bank
  - Building Unit Demand — 22,400 x 0.006 kW/sq.ft. = 134.4 kW

STEP 4

Load Schedule Demand Calculation: (Method two)

The following load schedule: (Work in kW using conversion factors from page 5311.7).

Lighting	28 kW
Air Conditioning	110.6 kW (Total of two units)
Receptacles	28 kW
Spare	17 kW

- Load Schedule Demand (kW = Sum of Load x D.Factor) for each type of load

Lighting	28 kW x 0.9 = 25.2 kW
Air Conditioning	55.3 kW x 1.0 = 55.3 kW (1st unit)
	55.3 kW x 0.8 = 44.2 kW (2nd unit)
Receptacle	28 kW x 0.1 = 2.8 kW
	Total Demand = 127.5 kW

STEP 5

– Estimated Demand Selection:
If the Square Foot Demand (SFD) divided by the Load Schedule Demand (LSD) is between .8 and 1.2, inclusive, choose the Square Foot Demand as the Estimated Demand Selection. If SFD/LSD is outside the .8 to 1.2 range, choose the lesser of the two as the Estimated Demand. However, if the LSD exceeds the change–out value of the selected transformer, the LSD should be checked for accuracy of information. Once a more accurate value is determined, the choice of transformer size should be made. If the load is for a chain store, an effort should be made to find out if there is an existing store in our service territory that is the same square footage and load profile. The Commercial Customer Demand Listing (Superdata Book) can be used to make a comparison between the SFD and LSD.

Peak KVA of similar accounts in Superdata Book (Customer #1 & Customer #2)

Customer #1 = 129 kW
Customer #2 = 133 kW

Estimated Peak demand = Average Demand = $\frac{129 + 133}{2}$ = 131 kW

STEP 6

Equipment Selection:
– Permanent Facilities
– Conduit, substructures and transformer pads to be sized in accordance with UG Construction Standard 3942.

Transformer:

– For Transformer Loading refer to Design Standard 5621.
– Select transformer size based on the estimated demand selection value obtained in Step 4.

For this example:

Estimate result in 150 kVA per 5621.1

Secondary & Service:

– Use PMWORKS to determine size.

BREAK EVEN ANALYSIS

When there is a clear understanding of the end use of the customer's building, use the results obtained with the Demand Estimating Worksheet. If, however, it is not clear what the building's initial use is or the load is not well defined, then a "Break Even Analysis" can be used. This will compare installing less capacity initially vs. full capacity.

A Break Even Year Matrix is shown on page 5311.8. Inputs to the matrix are the initial and ultimate transformer sizes. The output of the matrix is the number of years the installation of the ultimate transformer must be delayed to justify installing the smaller unit initially. At the end of the break even year, the total present value cost of installing and replacing the the smaller transformer will equal the total cost of initially installing the ultimate transformer.

Good judgment must be used forecasting the ultimate building use and demand. Consider similar buildings in the area with comparable floor space and similar customers in the service territory.

REFERENCES:

1. Design Standard 5621, Initial Transformer Design Loading for Balanced Loads
2. Design Standard 5411, Voltage Drop and Flicker Nomographs Application Guide
3. Design Standard 5431, Underground Cable Voltage Drop and Flicker Nomograph
4. Design Standard 5432, Overhead Conductor Voltage Drop and Flicker Nomograph.
5. Service Planning Practices 392, Load Studies, Gas and Electric
6. Service Planning Practice 930, Energy Load Information Agreement

TABLE 1 – CUSTOMER CLASS SELECTION

BUSINESS TYPE	
OFFICES	Lending institutions, insurance brokers, real estate legal services, etc. (4 stories or less)
DEPARTMENT STORES	Sears, Mervyns, Woolworths or large shops
RETAIL STORES	Variety stores, general merchandise, or small shops
BANKS	Local, state and federal banking
MEDICAL OFFICES	Dentists, physicians and laboratories
MEDICAL HOSPITALS	Hospital complexes, 3 stories or less
RESTAURANTS (fast fd.)	McDonalds, Burger King, Wendy's
RESTAURANTS (dining)	Denny's, Black Angus, El Toritos
CONVENIENCE STORES	Stop and Go, 7–11, U–Totem, corner delis
GROCERY STORES, CLUB STORES	Major chains, i.e. Vons, Safeway, Lucky, Costco
HOTEL/MOTEL	Hotels or motels, i.e. Hilton, Holiday Inn, Motel 8
LIGHT COMMERCIAL/ INDUSTRIAL	Fabrication, light manufacturing, non–assembly line, product distributing, machine shops, auto repair shops, bakeries
MANUFACTURING	Heavy manufacturing, assembly line
WAREHOUSING	Storage, distribution

Contact Distribution Standards for customers not identified in Table 1.

TABLE 2 – MISC LOADING/CONVERSION

WELDERS:

Convert input amps of welder to kW using the following equation;

$$\text{single-phase input kW} = \frac{\text{serving voltage x input amps x .9(PF)}}{1000}$$

$$\text{three-phase input kW} = \frac{\text{serving voltage x input amps(*) x .85(PF)xI.73}}{1000}$$

(*) input amps per phase
1 or 2 welders apply demand factor of .80 to the sum
3 to 5 welders apply demand factor of .60 to the sum
6 or more welders apply demand factor of .40 to the sum

Note: Use the same criteria for both transformer arc and motor generator welders.

X-RAY MACHINES:

Convert the rated kVA of x-ray equipment to kW by multiplying by a .9 p.f.

1 x-ray machine, apply demand factor of .80
2 x-ray machines, apply a demand factor of .60
3 or more x-ray machines, apply a demand factor of .32

MOTORS:

Convert the rated horsepower (hp) into kW using the following equation assuming 85% efficiency
1hp = .9kW
Convert the rated horse power (hp) into kVA using the following equation assuming .9pf.
– 1hp = 1kVA

TABLE 3 – COMMERCIAL DIVERSITY FACTORS

The following commercial diversity factors apply:

1 customer	1.00
2 customers	.90
3 customers	.80
4 customers	.70

THREE-PHASE KW CONVERSION FACTORS

KW 3Ø = AMPS. X 0.306 for 120/208
0.353 for 120/240
0.707 for 277/480

THREE-PHASE KW CONVERSION CALCULATION

$$\text{KW} = \frac{\text{Amps (Voltage line to line)(0.85pf)(1.732)}}{1000}$$

DEMAND ESTIMATING WORKSHEET

WORK ORDER NO.	DPSS NO.
JOB LOCATION	JOB NAME

This worksheet provides values of kW demand for new customers that may be used for sizing distribution transformers and services.

TRANSFORMER NO:	PANEL SIZE: Amps	SERVICE VOLTAGE: / Volts	PHASE:	WIRE:	SELECTED TRANSFORMER SIZE: kVA

Building or Serv. Pt.	SQUARE FOOT DEMAND: Bldg.sq.ft. x kW/sq.ft. = Demand in kW	Type of Load	LOAD SCHEDULE DEMAND: Total Load x D.Factor = Demand in kW
	x = kW		x = kW
	x = kW		x = kW
	x = kW		x = kW
	x = kW		x = kW
Total	kW	Total	kW

TRANSFORMER NO:	PANEL SIZE: Amps	SERVICE VOLTAGE: / Volts	PHASE:	WIRE:	SELECTED TRANSFORMER SIZE: kVA

Building or Serv. Pt.	SQUARE FOOT DEMAND: Bldg.sq.ft. x kW/sq.ft. = Demand in kW	Type of Load	LOAD SCHEDULE DEMAND: Total Load x D.Factor = Demand in kW
	x = kW		x = kW
	x = kW		x = kW
	x = kW		x = kW
	x = kW		x = kW
Total	kW	Total	kW

LOAD DENSITY

Type of Building:	kW/sq.ft. *Climate Zone 1	kW/sq.ft. *Climate Zone 2
☐ Office small (<40k sq. ft.)	0.006	0.007
☐ Office large (>40k sq. ft.)	0.004	0.005
☐ Retail Store	0.005	0.006
☐ Department Store	0.004	0.005
☐ Bank	0.006	0.007
☐ Medical Office	0.008	0.009
☐ Hospital	0.007	0.008
☐ Restaurant (fast food)	0.022	0.024
☐ Restaurant (dining)	0.014	0.016
☐ Bio–Medical	0.016	0.018
☐ Grocery/Conv. Store (<40k sq. ft.)	0.011	0.012
☐ Grocery/Conv. Store (>40k sq. ft.)	0.009	0.010
☐ Hotel/Motel	0.004	0.005
☐ Light Commercial	0.007	0.008
☐ Manufacturing	0.009	0.010
☐ Warehousing	0.005	0.006
☐ School	0.005	0.006
☐ Church	0.007	0.008

DEMAND FACTORS BY TYPE OF LOAD

Type of Load	D.FACTOR
☐ Lighting	0.9
☐ Air Conditioning	
1st unit	1.0
2nd through 5th unit	0.8
6th and up unit	0.7
☐ Motors	
Continuous Use	0.9
Elevator/Process	0.8
Equipment Machine Shop	0.5
Machine Tools	0.3
☐ Heating (Induction/ Resistance) Largest unit	1.0
Balance	0.5
☐ Computers	0.8
☐ Receptacles	0.1
☐ Commercial Cooking	0.4
☐ Resistance Welders	0.6 to 1.2
☐ Arc Welders	
Largest unit	1.0
Balance	0.5

SQUARE FOOT DEMAND (SFD) / LOAD SCHEDULE DEMAND (LSD) = COMPARISON RATIO (CR)

If $0.8 \leq CR \leq 1.2$, choose SFD as Estimated Demand.
If $CR < 0.8$ or $CR > 1.2$, choose the lesser (SFD or LSD) as the Estimated Demand.

NOTE: CONTACT DISTRIBUTION STANDARDS TO MODIFY DEMAND FACTOR FOR SPECIAL SITUATIONS. FURTHER ANALYSIS SHOULD BE DONE IF THE COMPARISON RATIO IS GREATER THAN 1.2.

Submitted by:_____ Approved by:_____
Project Management Supervisor

* Climate zones are same as contamination zones. See Overhead Standards page 287. Page _____ of _____

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CONVERSION FACTORS

277/480 VOLT
THREE PHASE, FOUR WIRE *
(PF = .85, MOTOR EFFICIENCY = 85%)
LOADS ARE ASSUMED BALANCED

To Get ===>	Amps	kW	kVA	Tons A/C	Motor HP
Multiply Amps by	1.00	.71	.83	.55	.83
" kW by	1.42	1.00	1.18	.78	1.18
" kVA by	1.20	.85	1.00	.67	1.00
" Tons A/C by	1.80	1.28	1.50	1.00	1.50
" Motor HP by	1.20	.85	1.00	.67	1.00

120/208 VOLT
THREE PHASE, FOUR WIRE *
(PF = .85, MOTOR EFFICIENCY = 85%)
LOADS ARE ASSUMED BALANCED

To Get ===>	Amps	kW	kVA	Tons A/C	Motor HP
Multiply Amps by	1.00	.31	.36	.24	.36
" kW by	3.27	1.00	1.18	.78	1.18
" kVA by	2.78	.85	1.00	.67	1.00
" Tons A/C by	4.16	1.28	1.50	1.00	1.50
" Motor HP by	2.78	.85	1.00	.67	1.00

120/240 VOLT
SINGLE PHASE, THREE WIRE *
(PF = .90, MOTOR EFFICIENCY = 85%)
LOADS ARE ASSUMED BALANCED

To Get ===>	Amps	kW	kVA	Tons A/C	Motor HP
Multiply Amps by	1.00	.22	.24	.16	.24
" kW by	4.63	1.00	1.11	.74	1.11
" kVA by	4.17	.90	1.00	.67	1.00
" Tons A/C by	6.25	1.35	1.50	1.00	1.50
" Motor HP by	4.17	.90	1.00	.67	1.00

* Factors for 208 volt, 240 volt, or 480 volt three phase, three wire systems can be converted by using the corresponding table for 120/208 volt, 120/240 volt, 277/480 volt three phase, four wire systems.

120/240 VOLT
THREE PHASE, FOUR WIRE *
(PF = .85, MOTOR EFFICIENCY = 85%)
LOADS ARE ASSUMED BALANCED

To Get ===>	Amps	kW	kVA	Tons A/C	Motor HP
Multiply Amps by	1.00	.35	.42	.28	.42
" kW by	2.83	1.00	1.18	.78	1.18
" kVA by	2.41	.85	1.00	.67	1.00
" Tons A/C by	3.61	1.28	1.50	1.00	1.50
" Motor HP by	2.41	.85	1.00	.67	1.00

* Factors for 208 volt, 240 volt or 480 volt three phase, three wire systems can be converted by using the corresponding table for 120/208 volt, 120/240 volt or 277/480 volt three phase, four wire systems.

NOTE: CONTACT DISTRIBUTION STANDARDS FOR CONVERSION FACTORS NOT IDENTIFIED.

BREAK EVEN YEAR MATRIX
INITIAL VS. ULTIMATE TRANSFORMER REQUIREMENT

277/480 Secondary Voltage (Minimum Change–Out Delay Required to Justify Initial Installation Of Smaller Unit (In Years)

Ultimate Transformer (KVA) \ Initial Transformer Size (KVA)	300	500	750	1000	1500
2000	2	1	4	2	4
1500	2	2	6	5	X
1000	3	3	>10	X	X
750	3	6	X	X	X
500	9	X	X	X	X

120/208 Secondary Voltage (Minimum Change–Out Delay Required To Justify Initial Installation Of Smaller Unit (In Years)

Ultimate Transformer (KVA) \ Initial Transformer Size (KVA)	225	300	500	750	1000
1500	2	3	2	2	4
1000	3	4	2	4	X
750	5	7	6	X	X
500	7	>10	X	X	X
300	7	X	X	X	X

NOTES:

1. Install the smaller size transformer unless the ultimate size transformers will be required prior to the breakeven year shown in the table above. For example, in the case of installing a 120/208 volt, 500 KVA unit initially where a 750 KVA unit initially where a 750 KVA unit will be rquired ultimately, the 500 KVA should be used if it will meet customer load requirements for at least 6 years.
2. Table values assume service cable will be sized to match transformer.

SCOPE

This design standard provides criteria for the proper selection of Electric Vehicles (EV) kW demand based on charger level and usage. These criteria were established to provide a uniform demand estimate for various sizes and configurations.

DEFINITIONS

- Dwelling Type – Refers to the classification of a residential dwelling as either single-family detached (no common walls with another dwelling, i.e., subdivision), single-family attached (one common wall or condominium/townhouse), multi-family (two or more common walls such as apartments) and mobile home (regardless of length and width).
- Diversity Factor – Refers to a multiplier applied to the sum of the individual service point (customer) demands connected to any single-phase or three-phase Electric Distribution System.
- Electric Vehicle (EV) Load – Refers to the additional residential load required to charge an electric vehicle.

CRITERIA

A. EV Demand Selection

1. There are several EV charging technologies in use today. Different EV manufacturers have different preferences. Table 1 describes the standard categories of charging technology as defined by the U.S. Department of Transportation (USDoT).

TABLE 1

USDOT CHARGING SYSTEM DEFINITIONS		
SYSTEM TYPE	**AC**	**CHARGE TIME**
Level 1 (Homes)	120V 1 kW	1-hour charge provides ~ 3.7 mi of range
Level 2 (Homes, Workplace, and Public)	240V 3.0 kW – 19.2 kW	1-hour charge produces ~ 9.3-18.6 mi of range
Direct Current Fast Charging (DCFC) (Public)	400V – 1,000V DC 50 kW – 350 kW	30-minute charge produces ~ 80.8 mi of range

2. An EV charging infrastructure is very different from the gasoline-filling station model. EVs require charging facilities in places where cars are typically at rest. Table 2 summarizes the most common models for charging EVs.

TABLE 2

EV CHARGING MODELS: HOME, WORKPLACE, AND PUBLIC			
LOCATION	**DESCRIPTION**	**TYPICAL CHARGING SYSTEMS**	**TYPICAL CHARGING OPPORTUNITY TIME**
Home	Single and multi-family dwellings, typically with garages or assigned parking	Level 1 or Level 2	4-16 hours (overnight)
Workplace	Customer / Employee parking	Level 2	8-12 hours
Public	Public parking garages or lots, commercial charging stations, highway rest areas	Level 2 or DCFC	2+ hours

3. The most common type of EV Chargers are Level 1 (120V) and Level 2 (240V) chargers, and demand can vary depending on the manufacturer. The EV kW demand can vary for Level 1 between 1.2 kW to 2.4 kW and Level 2 from 3.0 kW to 19.2 kW. The DCFC are most common in Tesla charging stations ranging from 75 kW to 250 kW superchargers.

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B. All chargers are divided into the following two classes:

1. Non-Load Management Controlled Chargers.

   a. When one or more non-load-controlled EV charging stations are included in a design, add them without using any diversity (DF = 1.0).

   b. Example:

      1) Charger 1 has a single 100 kW port fed from a single 100 kW power unit (100 kW design), and Charger 2 has a single 200 kW port fed from a single 200 kW power unit (200 kW design). If one 100 kW single port power unit and one 200 kW single port power unit are installed together, the total design load is 300 kW (100 kW + 200 kW).

2. Load Management Controlled Chargers

   a. Engineering recommends reaching out to the customer for the actual charging information/cut sheet to correctly size the transformer for these charging units.

   b. An approved **Deviation Request** will be required when Load Management Controlled Sites are being proposed.

   c. Examples:

      1) Charging Station A has 4 – 250 kW charging ports per power unit. Each power unit can only supply a maximum of 387 kW (the load control limit). Therefore, the design should be for 387 kW and not 250 kW x 4 = 1,000 kW.

      2) Charging Station B has 2 – 350 kW ports per 350 kW power unit. Therefore, the design should be for 350 kW (the load control limit) and not 350 kW x 2 = 700 kW.

REFERENCES

I. 2022 SDG&E Electric Vehicle Supply Equipment Standards, Sections 3.00 and 3.60

II. U.S. Department of Transportation, Charger Types and Speeds

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SCOPE

This design standard establishes the criteria for estimating single-phase air-conditioning requirements. This includes kW ratings and starting currents.

CRITERIA

A. Tons of Air Conditioning and BTUs of Cooling

1. Tons of air conditioning refers to the amount of heat an air conditioner can remove in a one-hour period. One full ton of air conditioning is equivalent to the removal of 12,000 BTU/HR of heat and will normally cool an area from 200 to 600 square feet of floor space.

   a. A 1 ton air conditioner would be rated at 12,000 BTU/HR.

   b. A 3 ton air conditioner would be rated at 36,000 BTU/HR.

   c. A 5 ton air conditioner would be rated at at 60,000 BTU/HR.

B. Air Conditioning – Horsepower

1. When used in reference to an air conditioner, horsepower (HP) generally refers to the rating of the compressor of the equipment only. The relationship of compressor horsepower to tons of cooling varies.

   a. The horsepower to tons ratio is generally 1.5 HP to 1 TON of refrigeration. This does not include the HP rating of auxiliary fans, pumps, motors, etc.

   b. The horsepower to kVA ratio is generally 1 HP to 1 kVA. This assumes an 85% efficiency and 90% power factor.

C. KW Rating of Air Conditioners

1. The ratio of kW to TONS of cooling is approximately 1.35 to 1.

   a. Discretion should be exercised when using the average relationships and ratios above to positively rate individual equipment without seeing it. Within the two general types described above, there is much individual variation from one make and model to another. The most reliable means of rating individual equipment is to take its total nameplate amperage and calculate the kW or HP rating using the above relationships as a general guide.

   b. When 240V, single-phase service is provided to loads that include air conditioners, the following starting currents should be used as a guide for voltage flicker calculations (actual amperage may be found on the equipment nameplate as locked rotor amps or L-R):

TABLE 1

STARTING CURRENT FOR 240V 1Ø AIR CONDITIONERS	
AIR CONDITIONER SIZE	**STARTING CURRENT (ASSUMES 5.5 TIMES MOTOR RUNNING CURRENT)**
Up to 30,000 BTU/HR (2-1/2 ton)	85A
31,000 – 42,000 BTU/HR (2-1/2 to 3-1/2 ton)	85 – 120A or 110A Average
43,000 – 60,000 BTU/HR (3-1/2 to 5 ton)	120 – 170A or 150A Average

REFERENCES

I. None

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

SINGLE-PHASE AIR CONDITIONING REQUIREMENTS

DM5321.1

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SCOPE

The design standard was established to provide uniform demand (kW) estimating guidelines for various residential dwelling types, in accordance with the states building codes, National Electrical Code (NEC) and internal residential studies.

DEFINITIONS

- Base Load – Refers to those dwellings whose electrical load consist of "Plug Loads" and lighting loads.
- Distributed Generation (DG) – Refers to any type of local generation (photovoltaic, wind, or other) connected to the electric supply behind the meter.
- Dwelling Type – Refers to the classification of a residential dwelling as either single-family detached (no common walls with another dwelling, i.e., subdivision), single-family attached (one common wall or condominium/townhouse), multi-family (two or more common walls such as apartments), ADU's (less than 700 square foot homes) and mobile home (regardless of length and width).
- Electric Vehicle (EV) Load – Refers to load required to charge an electric vehicle. The EV kW demand varies for Level 1 - 1.2kW to 2.4kW and Level 2 - 3.0kW to 19.2kW.
- Major Appliances – Refers to HVAC, Electric Heat Pump Heating, Electric Water Heating and Electric Cooktop/Range.
- Plug Loads – Consists of Washer, Dryer, Refrigerator, Microwave, Computer and other plug-in devices.
- Battery Energy Storage System (BESS) – Home battery pack design to charge during solar hours and discharge or shave-off peak load.
- Residential Diversity Factor – Refers to a multiplier applied to the sum of the individual service point demands connected to any single-phase or three-phase electric distribution system.
- Residential Demand Factor – Refers to a multiplier applied to the maximum demand to the total connected load to any single-phase or three-phase electric distribution system.

CRITERIA

A. Residential Demand Selection

The residential kW demand per unit selection is dependent on the dwelling type, dwelling square footage, and major appliance usage or connected appliances.

1. Table 1 provides the kW demand per unit selection for dwellings in a project that is less than 3,400 square feet. Select a square footage category based on the dwelling type. If square footage is not obtainable, select a square footage category that is typical for that dwelling type.
2. Table 2 provides the kW demand selection for a dwelling that is 3,400 square feet or greater, i.e., a custom dwelling. To calculate the dwellings total kW demand, determine what connected appliances from Table 2 apply, and multiply by the appropriate demand factor. The sum of these totals will provide an estimate for the dwelling.
3. Table 3 provides diversity factor(s) depending on the number of meters. Section B provides additional details.

   NOTE: Distributed Generation (if type and quantity are known) should NOT be included in the demand estimation.
4. Section C establishes standardized transformer sizing by customer count, incorporating anticipated load impacts from electrification adoption in San Diego County. See DM5611 for additional information.
5. The total demand for each Dwelling unit is determined by adding the appropriate values from the Demand Category, see Table 1 and examples below.
6. BESS are designed to work with the dwelling's roof top solar system; charge the battery during high solar export, typically 8am to 4pm and discharge during high demand peaks, typically, 4pm – 9pm. In theory, this methodology/design should offset and not have an impact on the dwellings estimated load.

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If the dwelling unit does not have a roof top solar system but has batteries, then the battery should be considered as a load when estimating the dwelling's demand. Engineering recommends communication with the developer/customer to understand the dwelling's load management design. If no information is acquired, then the battery's nameplate storage capacity, in kW should be added to the value in the Demand Category selected.

B. Residential Diversity Selection

The residential diversity factors are applied based on the number of meters being served, diversity factor category, and dwelling type. The following guidelines shall apply when determining the diversified demand from Table 3:

1. The total demand is based on the sum of the individual service points (meters) outlined in Table 1, multiplied by the appropriate diversity factors outlined in Table 3. See the examples provided.

C. Standardizing Transformers

When adding a new transformer or replacing an existing one, continue using tools such as VDFL (Voltage Drop and Flicker Limit) or other transformer loading assessment methods to determine the appropriate size. These tools help ensure that new transformers can handle the required load without causing voltage drops or flicker issues.

As electrification increasingly influences demand estimates, a general rule of thumb is that a single-phase transformer serving four or more customers should be sized at a minimum of 50 kVA.

TABLE 1: RESIDENTIAL DWELLING KW DEMAND PER UNIT

DWELLING TYPE	SQUARE FOOTAGE	KW DEMAND CATEGORIES (i)			
		BASE LOAD AIR COND.	BASE LOAD ELEC HEATING	BASE LOAD ELEC. WATER HEATING	ALL ELECTRIC HOME
Single-Family Detached	700–1299	5.8	6.3	7.9	10.4
	1300–1999	7.2	8.1	8.7	11.6
	2000–2999	9.0	9.6	9.7	13.3
	3000–3399	10.5	10.5	10.5	14.6
Single-Family attached (condo/townhouse)	0–1299	4.6	4.8	7.1	9.4
	1300–1999	6.2	6.8	7.7	10.8
	2000–2999	7.6	7.7	8.2	12.0
Multi-Family (apartments)	0-699	4.7	4.9	7.0	8.0
	700–1299	5.2	5.4	7.1	8.4
	1300–1999	6.2	6.6	7.4	9.4
Mobile Homes	0–1299	4.9	5.2	6.9	8.3
	1300–1999	7.0	7.0	7.2	10.3
ADU (vi)	0-699	4.3	4.5	6.9	7.2
	700-1299	5.6	6.0	7.1	8.4

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TABLE 2: CUSTOM RESIDENTIAL DWELLING KW DEMAND (3,400 SQ. FT. OR GREATER)			
DEMAND CATEGORIES	**DEMAND FACTOR**	**CONNECTED APPLIANCES** (iii)	**KW DEMAND PER UNIT ESTIMATE**
LED Lights	0.50	Internal lighting (LED)	1-2
HVAC	0.50	3 to 7-1/2 TON single or multiple units	1.35 kW/TON
Heat Pump	0.50	Space Heater or Water Heater	7.2
Major Appliances	0.50	Water heater Clothes dryer Dishwasher Heat strip	4.5 ea. 7.2 ea. 1.2 ea. 5-15 ea.
	0.80	Electric Cook Top/Range	12
Exterior Loads	0.50	Tennis court lighting Swimming pool and SPA equipment Exterior lighting	Varies
Other Loads	0.40	Convenience outlets Wine cellar Sauna Small motor load	Varies
EV Load (ii)	0.50	Residential EV Charging Station	7.2

TABLE 3: RESIDENTIAL DIVERSITY FACTORS			
NUMBER OF METERS	**DIVERSITY FACTOR CATEGORIES**		
	TRANSFOMER LEVEL	**SECONDARY/SERVICE LEVEL** (v)	
	BASE LOADS + APPLIANCES	**SINGLE-FAMILY DETACHED**	**MULTI-FAMILY, SINGLE-FAMILY ATTACHED**
1-2	1	1	1
3-8	0.7	0.85	0.7
9-10	0.65	0.8	0.65
11-12	0.6	0.75	0.65
13+	0.5	0.7	0.6

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EXAMPLE 1:

Determine the estimated load of an all-electric 12-lot subdivision with single-family detached dwellings ranging from 2,000–2,800 square feet:

Use Tables 1 and 3 to determine the load and diversified demands for this transformer/s and secondary/service system.

- Dwelling type = single-family detached
- Square footage range = 2000 - 2999
- Demand per unit from Table 1 = 13.3 kW
- Diversity factors from Table 3 (Transformer) = DF = 0.6 (12 meters)
- **Total diversified demand kW (Transformer)** = (12 x 13.3 kW x 0.6) = 95.76 kW
- Diversity factors from Table 3 (Services) = DF = 0.75
- **Total diversified demand kW (each service)** = (12 x 13.3 kW x 0.75) = 119.7 kW/12 = 9.97 kW

The diversified demand values of 95.76 kW and 9.97 kW would be used to size the transformer and each service, respectively. For this subdivision example, and based on the results of the VDF calculations, one viable option to serve the load is the installation of two 50 kVA HTS transformers.

EXAMPLE 2:

Determine the kW demand estimate for a custom home that is 4,500 square feet with the following appliances being served:

Connected Appliance Load Breakdown

- Air conditioning (2 units) = 1 - 3 TON, 1 - 5 TON
- Electric range = 12 kW
- Water heating = 4.5 kW
- Clothes dryer = 7.2 kW
- Heat pump space heater = 7.2 kW
- Tennis courts = 4 kW
- Swimming pool = 1 - 7 ½ HP, 1 - 1 ½ HP
- Sauna = 4 kW
- Internal lighting = 5 kW
- EV Load (ii) = 2 - 7.2 kW

The diversified kW demand for a custom home is obtained from Table 2 as follows:

1. Group each appliance by their respective Demand Category
2. For each group, sum the connected appliance loads, apply the appropriate demand factor, and then add the resulting values
3. The sum of these values represents the total kW demand

Demand Category (iv)		Sum of Connected Load		Demand Factor		Demand
Lights	=	5.0 kW	X	0.50	=	2.50 kW
HVAC	=	10.8 kW	X	0.50	=	5.40 kW
Heat Pump	=	7.2 kW	X	0.50	=	3.60 kW
Major Appliances	=	11.7 kW	X	0.50	=	5.85 kW
Electric Range	=	12.0 kW	X	0.80	=	9.60 kW
Exterior Loads	=	12.1 kW	X	0.50	=	6.05 kW
Other	=	4.0 kW	X	0.50	=	2.00 kW
EV Load (ii)	=	14.4 kW	X	0.50	=	7.20 kW
				Total diversified kW demand		42.20 kW

The total diversified kW demand of 42.20 kW would be used to size the transformer and secondary/service system. For this example, and based on the results of the VDF calculations, one viable option to serve the load is the installation of one 50 kVA HTS transformers.

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NOTES

(i) The kW demand values provided in Table 1 reflect the estimated demand requirements for each category and include electrification and electric vehicle loads where applicable within the dwelling type.

(ii) Most common type of Residential Chargers are Level 1 (120V) and Level 2 (240V) chargers vary depending on the manufacturer; For Level 1 - 1.2 kW to 2.4 kW and for Level 2 - 3.0 kW to 19.2 kW. Engineering recommends contacting the developer/customer for actual charging level information/cut sheet to correctly size the charger. If the EV charger information is unavailable it is recommended to use NEC 220.57 requirements which state 7.2 kW per EV charger. If more than one EV charger is installed behind the same meter, apply a demand factor (DF) of 0.5 to each additional EV charger and add to the base load for that dwelling type.

(iii) Use the kW demand per unit estimate in Table 2 as a check for submitted connected loads. These estimates can also be used if connected loads are not known.

(iv) Refer to DM5324, On Demand Water Heating.

(v) See OH711 and UG4000 standards for secondary and service conductor/cable.

(vi) The ADU category shall be used for dwelling units below 700 square feet.

REFERENCES

I. Commercial and Industrial Demand Estimating 5311.7 - Conversion Factors

II. Electric Distribution Design Manual 5324, On Demand Water Heating

III. Electric Distribution Design Manual 5611, Single-Phase Transformer Application

IV. Overhead Construction Standards 711, Wire Tables

V. Underground Construction Standards Section 4000, Tables

VI. National Electric Code Handbook 2023, Section 220.5 & 220.57

VII. California Code of Regulations, Title 24

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SCOPE

While Demand (Tankless) Water Heaters are not required by Title 24 initiatives, this design standard provides guidance regarding the electrical (kW) demand of heat pumps and electric tankless water heaters if proposed, while also addressing the effects a single residence could have on the electric utility system.

DEFINITIONS

- Heat Pump Water Heater (HPWH) – Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. Heat pump water heaters are also commonly referred to as hybrid electric water heaters. A heat pump water heater takes the heat from surrounding air and transfers it to water in an enclosed tank. During periods of high hot water demand, heat pump water heaters switch to standard electric resistance heat (hence they are often referred to as "hybrid" hot water heaters) automatically.
- On Demand Tankless Water Heaters – Tankless electric water heating is a product that uses electricity to provide instant hot water as needed without the use of a storage tank in residential homes.
- Dwelling Type - Refers to the classification of a residential dwelling as either single-family detached (no common walls with another dwelling, i.e., subdivision), single-family attached (one common wall or condominium/townhouse), multi-family (two or more common walls such as apartments) and mobile home (regardless of length and width).
- First Hour Rating – Refers to how much water will be consumed in any given hour before the tank must refill and reheat more incoming water.
- Gallons per Minute (GPM) – The unit of measurement for the maximum flow rate required by the hot water system.

CRITERIA

A. Residential Applications

1. Electric on Demand Tankless Water Heaters

   a. The average tankless water heaters (reference Table 6) provided hot water at a rate of 2-5 gallons per minute. The larger the unit, the more energy is expected to be used, i.e., average kW for On Demand Tankless Electric Water Heater: 30.75 kW.

   b. The water heating capacity of the electric tankless water heaters are limited to the ability of the household's electrical system. Most homes in the U.S. have an electrical service in the range of 100-150A, while older homes tend to have 100A or lower. Most homes are limited to an electric tankless water heater with a maximum flow rate of 3.0 GPM due to the large amount of power required, which is barely enough to service two simultaneous hot water needs.

      1) Multiple tankless water heaters would need to be installed to handle simultaneous hot water fixtures if a single unit cannot supply.

B. Tankless Water Heater Sizing

1. Two primary factors to consider when determining correct size of a tankless water heater:

   a. Maximum Flow Rate – Determined by the number of fixtures that will be used at the same time, and the flow rate of each of those fixtures. This is the sum of gallons per minute for all end uses within a given hour.

      1) The system water pipe sizing can also have an effect on the flow volume.

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Table 1	
Fixture	**GPM***
Shower	1.8
Kitchen	1.8
Bath	0.5
LEGEND *Appliance Efficiency Regulations California Code of Regulations Title 20, Sections 1601 Through 1609.	

b. Temperature Rise – The difference between the desired set temperature of the hot water, and the inlet or ground water temperature from the supply (reference Example 1).

1) Since building supply temperature can vary throughout the year based on the season, temperature rise should be calculated based on the coldest days of the year.

Table 2	
Average Ground Water Temperature in SDG&E Territory	
City	**Temp. (F)**
Chula Vista	62
Oceanside	58
San Diego	65
San Clemente	65
Vista	65
Average	**63**

2) Examples based on the average in Table 2:

a) Maximum temperature per California Code Regs. Title 22, 81088 – Fixtures, Furniture, Equipment, and Supplies: Mfg. Res. Hot Water Temp. (F) of 120, would result in a Std. Res. Temp. Rise of 57.

b) A Mfg. Res. Hot Water Temp. (F) of 140 would result in a Max. Res. Temp. Rise of 77.

c) Minimum temperature per California Code Regs. Title 22, 81088 – Fixtures, Furniture, Equipment, and Supplies: Res. Hot Water Temp. (F) of 105, would result in a Min. Res. Temp. Rise of 42.

C. Residential Demand Estimating

The Residential Demand Estimating is dependent on the dwelling type, dwelling square footage, and concurrent water usage.

1. Equation to calculate kW demand:

$$Demand\ (kW) = \frac{\text{Flow Rate (GPM) x Temperature Rise (F) x}}{\underline{0.146}\ \text{Efficiency}}$$

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2. Table 3 provides the average kW demand for dwellings below 3,000 square feet. To determine the kW demand from Table 3, select a square footage category and calculate the Maximum Flow Rate or Total Water Use given the averages in Table 1. Next, determine the temperature rise from ground - residential temperatures are typically 120 to 125 degrees, and commercial temperatures can range from 140 to 180 degrees depending on the application.

   NOTE: A higher flow rate may increase the kW demand for residential/commercial applications.

3. Table 4 provides the average kW demand for dwellings 3,000 square feet or greater. To determine the kW demand from Table 4, calculate the Maximum Flow Rate or Total Water Use given the averages in Table 1. Next, determine the temperature rise from ground - residential temperatures are typically 120 to 125 degrees, and commercial temperatures can range from 140 to 180 degrees depending on the application.

   NOTE: For each additional 250 sq. ft., reference the Water Use Adder and kW Adder values depending on the square footage.

NOTE: Limited data is available for determining estimation of demand and the National Electric Code does not specifically identify how to properly factor electric tankless water heaters. Assumptions on water usage are based on information captured from the Department of Energy (Federal), California Energy Commission and on demand electric water heating manufacturer literature referenced in Tables 5 & 6.

Table 3: Residential Demand Estimating

Dwelling Type	Square Footage			Concurrent Use in Gallons				105 F	(AVG) 120 F	140 F	AVG	NEC 220.53	
		Bedrooms	Baths	Shower	Kitchen	Bath	TOTAL WATER USE	kW	kW	kW	kW	AVG kW @ 75%	AVG kW @ 50%
SINGLE FAMILY DETACHED	0-1299	2	1.5	1	1		3.6	23.2	31.5	42.6	32.5	24.3	16.2
	1300-1999	3	2.5	1	1	1	4.1	26.5	35.9	48.5	37.0	27.7	18.5
	2000-2999	4	3.5	2	1		5.4	34.9	47.3	63.9	48.7	36.5	24.3
SINGLE FAMILY ATTACHED	0-1299	2	1.5	1	1		3.6	23.2	31.5	42.6	32.5	24.3	16.2
	1300-1999	3	2.5	1	1	1	4.1	26.5	35.9	48.5	37.0	27.7	18.5
	2000-2999	4	3.5	2	1		5.4	34.9	47.3	63.9	48.7	36.5	24.3
MULTI-FAMILY ATTACHED	0-1299	2	2	1	1		3.6	23.2	31.5	42.6	37.1	27.8	18.5
	1300-1999	3	2	1	1	1	4.1	26.5	35.9	48.5	42.2	31.7	21.1
MOBILE HOME	0-1299	2	1	1	1		3.6	23.2	31.5	42.6	37.1	27.8	18.5
	1300-1999	3	2	1	1	1	4.1	26.5	35.9	48.5	42.2	31.7	21.1
ADU	0-1299	2	1	1	-	-	1.8	11.6	15.8	21.3	18.5	13.9	9.3

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Table 4: Residential Demand Estimating (3000 Sq. Ft. Or Greater)										
Dwelling Type	Square Footage	Min. Bedrooms	Min. Bathrooms	Min. Water Use Baseline	Additional Demand for every 250 sq-ft above 3000 sq-ft					
					105 F	120 F	140 F	AVG	NEC 220.53	
									kW @ 75%	kW @ 75%
SINGLE FAMILY DETACHED	3,000+	4	3	5.4	34.9	47.3	63.9	48.7	36.5	36.5
				DEMAND (kW) Adder per every 250 sq-ft	**2.1**	**2.8**	**3.8**	**2.9**	**2.2**	**2.2**

Table 5						
Make	**Model**	**Capacity in Gallons**	**1 Hour Rating in Gallons**	**Voltage**	**Rated Ampacity**	**Kilo Watts (kW)***
A.O. Smith	HPTS-50	50	65	208-240	23.6	4.5
A.O. Smith	FPTU-50	50	66	208-240	23.6	4.5
Rheem	XE50T10H45UO	50	67	208-240	21.0	4.5
Rheem	PROPH50T2RH375-30	50	67	208-230	21.0	5.0

Table 6					
Make	**Model**	**Max Flow Rate in Gallons**	**Voltage**	**Rated Ampacity**	**Kilo Watts (kW)***
A.O. Smith	R4LA-280E	2.5	240	120.0	28.0
A.O. Smith	R4MA-320E	2.8	240	140.0	32.0
Rheem	RETEX-27	4.3	240	113.0	27.0
Rheem	RETEX-36	5.7	240	150.0	36.0

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EXAMPLE 1

The normal residential set temperature is 120 degrees Fahrenheit, and if the incoming water temperature is 55 degrees the resulting temperature rise is 65 degrees (120-55=65). Typically, residential temperatures are 120 to 125 degrees, and commercial temperatures can range from 140 to 180 degrees depending on the application.

NOTES

I. Fixed-appliance load – If there are four or more fixed appliances in the residence, 220.53 permits all of these loads to be totaled and then a demand factor of 75% applied.

II. The calculated load shall be the result of adding the loads from 220.30 (B) and (C). Feeder and service-entrance conductors whose demand load is determined by this optional calculation shall be permitted to have the neutral load determined by 220.22.

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III. General Load. The general calculated load shall be not less than 100 percent of the first 10 kVA plus 40 percent of the remainder of the following loads:

a. 1,500 volt-amperes for each 2-wire, 20-ampere small-appliance branch circuit and each laundry branch circuit specified in 220.16.

b. 33 volt-amperes/m^2 or 3 volt/amperes/ft^2 for general lighting and general-use receptacles. The floor area for each floor shall be computed from the outside dimensions of the dwelling unit.

c. The nameplate rating of all appliances that are fastened in place, permanently connected, or located to be on a specific circuit, ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and water heaters.

d. The nameplate ampere or kVA rating of all monitors and of all low-power-factor loads.

IV. Heating and Air-Conditioning Load. The largest of the following six selections (load in kVA) shall be included:

a. 100 percent of the nameplate rating(s) of the air conditioning and cooling.

b. 100 percent of the nameplate ratings of the heat pump compressors and supplemental heating unless the controller prevents the compressor and supplemental heating from operating at the same time.

c. 100 percent of the nameplate ratings of electric thermal storage and other heating systems where the usual load is expected to be continuous at the full nameplate value. Systems qualifying under this selection shall not be calculated under any other selection in 220.30©.

d. 65 percent of the nameplate rating(s) of the central electric space heating. Including integral supplemental heating in heat pumps where the controller prevents the compressor and supplemental heating from operating at the same time.

REFERENCES

a. National Electric Code 220.53

b. National Electric Code 220.30

c. Department of Energy

d. California Energy Commission

e. Energy Star

f. United States Environmental Protection Agency

g. Electric Tankless Water Heating: Competitive Assessment, Global Energy Partners, LLC, Lafayette, CA: 2005. 1285-5-04

h. Heat Pumps and Electric on Demand Tankless Water Heaters: Average kW demand, Pacific Energy Solutions Company, Menifee, CA: 2024: 24-09-001

i. Electric Distribution Design Manual 5322, Residential Demand Estimating, Table 1 & 2

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VOLTAGE DROP

5400
VOLTAGE DROP

PAGE	SUBJECT
5411	VOLTAGE DROP AND FLICKER APPLICATION GUIDELINE
5413	SECONDARY FLICKER
5414	DER VOLTAGE FLICKER REQUIREMENTS
5421	PRIMARY SYSTEM VOLTAGE FLICKER LIMIT CALCULATION
5425	TRANSFORMER PERCENTAGE VOLTAGE DROP

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VOLTAGE DROP

SCOPE

This standard describes the calculation method used to determine secondary and service voltage drops for Simple, Compound, and Complex systems.

DEFINITIONS

Simple Secondary System – A single service run from a transformer.

Compound Secondary System – A single service secondary run from a transformer with multiple services.

Complex Secondary System – A system using multiple secondary runs with service(s) attached to the end of each secondary.

APPLICATION

A. The total volt drop in the transformer and secondary/service system is to be limited to 4.2% (5V on 120V base per Design Manual 6211). The sizing of the secondary/service will depend on how much of the 4.2% is left after the transformer volt drop has been determined. The procedure is as follows:

1. Determine transformer volt drop percentage from Design Manual 5425.
2. Subtract transformer volt drop from total allowable volt drop of 4.2% to determine the available secondary/service volt drop.
3. If the volt drop limits cannot be met, tapped transformers can be used to reduce volt drop. Contact Distribution Workflow and Planning for further assistance.
4. See Design Manual 5222.1 Section A-1 for sample calculation of transformer loading in excess of 100%.

B. The estimated diversified demands used to determine load requirements shall be in accordance with the following:

1. Residential (Design Manual 5322)
2. Commercial (Design Manual 5311)

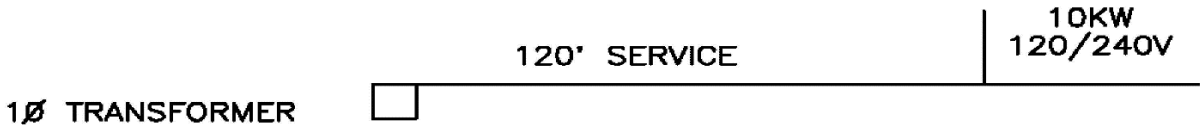
C. Equipment selection shall be made in accordance with the following:

1. Conduit, substructures, and pads are to be sized in accordance with Underground Construction Standard 3942.
2. Transformer (Design Manual 5621)
3. Secondaries and Service (Design Manuals 5431 & 5432)

CALCULATIONS

Use of the voltage drop and flicker nomograph is described in the following examples:

A. Simple System Voltage Drop Calculation (Refer to Nomograph in Design Manual 5431)



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VOLTAGE DROP AND FLICKER APPLICATION GUIDELINE

1. Demand refers to line "A" and given in KW or amps. The KW demand column includes a 90% power factor.
   a. Enter line "A" @ 10 KW
   b. Requires 1 - #2AL cable run for ampacity (First cables size on line "A" above 10 KW)
2. Length of Run refers to line "B" and given in feet.
   a. Enter line "B" @ 120 feet
3. Transition Line refers to line "E" and determines the cable or conductor requirements for a 2% voltage drop allowance when a line is drawn from the Demand to the Length of Run.
   a. Requires 1 - #2 AL cable run for voltage considerations (First cable size on line "E" above line drawn between demand and cable length). If a large cable is required due to cable ampacities (Line "A"), the larger cable is selected.
4. Cable or Conductor Size refers to line "D" and is used to determine the actual voltage drop for the cable selection required on the Transition Line.
   a. Enter line "D" @ 1 - #2AL cable run
5. Percentage Voltage Drop refers to line "C" and provides the actual voltage drop when a line is drawn from the Transition Line through the Cable or Conductor Size.
   a. 1.6% voltage drop, actual

B. Simple System Flicker Calculation

1. Determine the maximum percent flicker allowed for a three ton central air conditioner. The maximum permitted flicker is found by using the secondary flicker frequency chart on Design Manual 5431.1 (For multiple motors, add the frequency of the motor starts before using the chart).
   a. Air conditioning equipment is listed in group 1 and flicker is limited to 6%.
2. Determine the percent flicker through the transformer using the transformer flicker tables on Design Manual 5413.6 (For multiple motors, use the largest motor unless simultaneous starting is indicated on the engineering questionnaire).
   a. The air conditioner rating in tons must be converted to horsepower prior to determining the percent flicker through the transformer. 3 tons = 3 X 1.5 hp = 4.5 hp (Design Manual 5321).
   b. The percent flicker through the 25 KVA transformer is obtained from Table 5 on Design Manual 5413.6 as: 1.8% flicker, transformer
3. Using the voltage drop and flicker nomograph:
   a. Starting Current refers to line "A" and is given in air conditioning tons or locked rotor amps. Locked rotor (L – R_ amps refers to the amperage load demanded by the motor upon starting and may be obtained from the motor nameplate.
      1) Enter line "A" at 3 tons

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b. Transition Line refers to line "E" and determines the cable or conductor requirements based on the length of run used previously in voltage drop calculation 2.

c. Percent Secondary and/or Service Flicker refers to line "C" and is based upon the cable or conductor size selected previously in voltage drop calculation 4.

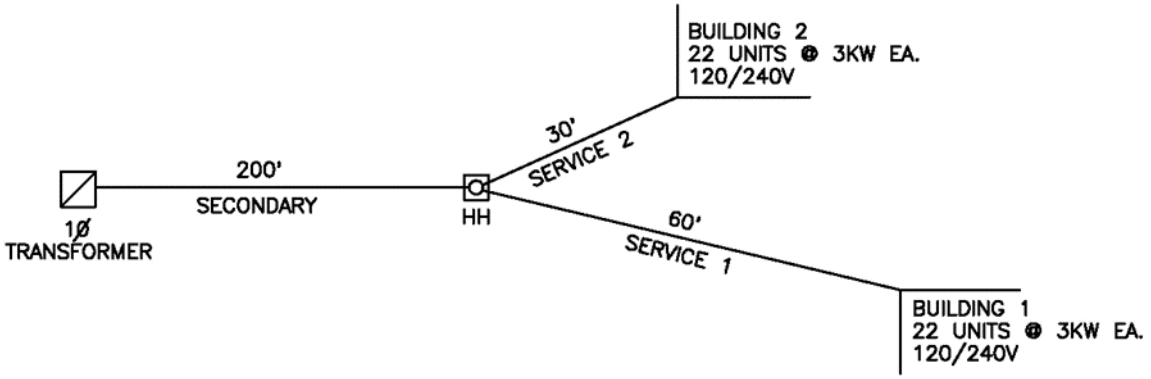
1) 3.3% flicker, secondary and/or service

d. Total Percent Flicker is equal to the sum of the percent flicker through the transformer and the percent flicker on the secondary and/or service.

1) 1.8% + 3.3% = 5.1% flicker, total

2) The maximum allowable flicker is normally six percent. However, this may be raised to seven percent for an existing customer served from an existing transformer, when an increase in transformer size would be required to meet the six percent limit.

C. Compound System Voltage Drop Calculation (Refer to Nomograph in Design Manual 5431.1)



1. Demand – Using the Residential Demand Estimating Standard: Design Manual 5322

   a. Services 1 & 2 = 33 KW each residential building (22 units @ 3 kw each)

   b. Requires 1 – 3/0 cable run for ampacity

   c. Secondary = 66 KW (44 units @ 3 kw each)

   d. Requires 3 – 3/0 cable runs for ampacity

2. Length of Run – Size of the secondary run using the total distance to the last customer.

   a. 260 feet

3. Transition Line – Using 66 kw demand on line "A" and 260 feet on line "B" and draw a straight line connecting these points.

   a. Requires 3 – 350 KCMIL AL cable runs for the secondary

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4. Percent Voltage Drop, Secondary – Using the actual Length of Run and Demand for the secondary (200 feet & 66 kw). Redraw the intersection point on the Transition Line and find the percentage voltage drop for 3 – 350 KCMIL AL cables at line "D".

    a. 1.2% voltage drop, actual

5. Percent Voltage Drop, Service – Using the remaining voltage drop allowance (2 – 1.2 = .8%) size for services

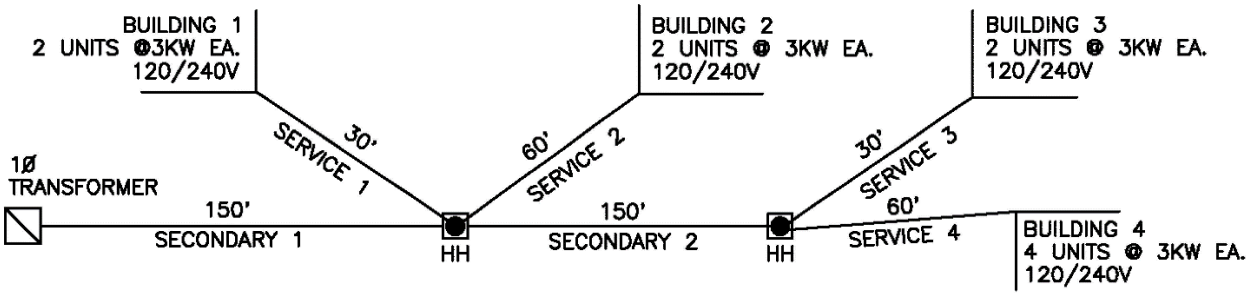
    a. Service #1 – Using the actual Length of Run and Demand for the service (60 feet & 33 kw). Redraw the intersection point on the Transition Line and find the service cable requirement from line "D" with a .8% voltage drop allowance.

        1) Requires 1 – 350 AL cable runs

    b. Service #2 – Using the actual Length of Run and Demand for the service (30 feet & 33 kw) and .8% voltage drop allowance determines the cable requirement from line "D".

        1) Requires 1 – 1/0 KCMIL cable run

D. Complex System



1. Demand using the Residential Demand Estimating Standard: Design Manual 5322

    a. Services 1, 2, & 3 – 6 kw (No diversity for less than four customers)

    b. Service 4 – 9 kw (4 units @ 3 kw each)

    c. Secondary #2 – 11.7 kw (6 units @ 3 kw each)

    d. Secondary #1 – 16.5 kw (10 units @ 3 kw each)

2. Length of Run – Size the secondary runs using the total distance to the last customer.

    a. 360 feet

3. Transition Line

    a. Secondary #1 – 16.5 kw demand at 360 feet requires 1 – 350 KCMIL AL cable run

    b. Secondary #2 – 11.7 kw demand at 360 feet requires 1 – 350 KCMIL AL cable run

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4. Percent Voltage Drop, Secondary – Using the actual Length of Run and Secondary Demand. Determine percentage voltage drop for the cables selected in Step 3.

   a. Secondary #1 – 16.5 kw demand, 150 feet, 1 – 350 KCMIL AL cable run has .65% voltage drop.

   b. Secondary #2 – 11.7 kw demand, 150 feet, 1 – 350 KCMIL cable run has .45% voltage drop.

5. Percent Voltage Drop, Service

   a. Services #1 & 2 are served from secondary #1 with a .65% voltage drop. The remaining voltage drop allowance for the service is 1.35%.

      1) Service #1 – 6 kw demand, 30 feet Length of Run, 1.35% voltage drop requires 1 - #2 AL cable run.

      2) Service #2 – 6 kw demand, 60 feet Length of Run, 1.35% voltage drop requires 1 - #2 AL cable run.

   b. Services #3 & 4 are served from secondaries #1 & 2 with a combined voltage drop of 1.1%. The remaining voltage drop allowance for the service is .9%.

      1) Service #3 – 6 kw demand, 30 feet Length of Run, .9% voltage drop requires 1 -#2 AL cable run.

      2) Service #4 – 6 kw demand, 60 feet Length of Run, .9% voltage drop requires 1 - #2 AL cable run.

REFERENCES

A. Design Manual 5311 – Three-Phase Demand Estimating Criteria

B. Design Manual 5321 – Single-Phase Air Conditioning Requirements

C. Design Manual 5322 – Residential Demand Estimating

D. Design Manual 5413 – Voltage Fluctuations (Flicker)

E. Design Manual 5431 – Underground Cable Voltage Drop and Flicker Nomograph

F. Design Manual 5432 – Overhead Conductor Voltage Drop and Flicker Nomograph

G. Design Manual 5621 – Initial Transformer Design Loading for Balanced Loads

H. Service Planning Manual 491 – Voltage Complaints

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SCOPE

This standard defines permissible levels of voltage flicker on the secondary distribution system. It shall be used by Planners when sizing transformers and secondary/service cables. The subject of primary flicker is discussed in Design Standard 5421.

PURPOSE

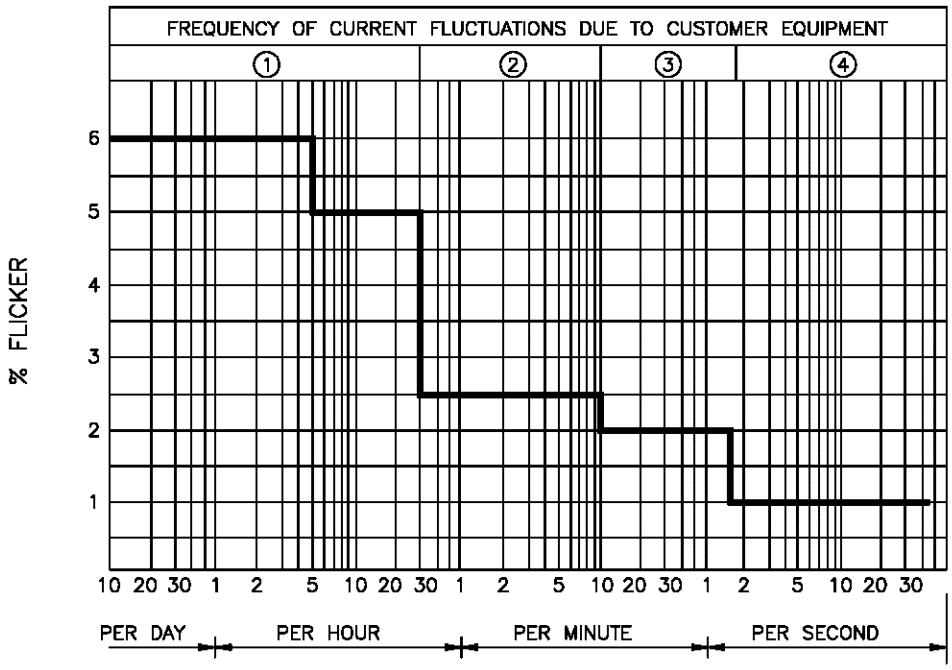
This standard provides a basis for selecting the transformer and secondary/service wires to prevent customer complaints from flickering lights and damage to sensitive electronic equipment.

DEFINITIONS

Secondary System Voltage Flicker, also known as secondary flicker, is defined as the percentage voltage fluctuation that occurs within the distribution transformer and secondary/service system. For calculation purposes, this standard assumes negligible primary system impedance.

CRITERIA

Sudden reductions in secondary system voltage or rapid voltage fluctuations affect the lumen output of lamps and may damage sensitive electronic equipment in a number of ways. Flicker refers to the variation in light output of lamps as well as sudden reductions/rapid fluctuations of voltage. The acceptable amount of secondary system voltage fluctuation as a function of frequency is illustrated in Figure 1. Secondary flicker that occurs in excess of these values is likely to result in customer complaints.



① HOUSE PUMPS
SUMP PUMPS
COMPRESSORS
AIR CONDITIONING EQUIP.
THEATRICAL LIGHTING
DOMESTIC REFRIGERATORS
OIL BURNERS

② SINGLE ELEVATOR
HOISTS
CRANES
Y–DELTA CHANGES ON
ELEVATOR–MOTOR–GENERATOR
X–RAY EQUIPMENT

③ ARC FURNACES
FLASHING SIGNS
ARC–WELDERS
MANUAL SPOT–WELDERS
DROP HAMMERS
SAWS
GROUP ELEVATORS

④ RECIPROCATING PUMPS
AUTOMATIC SPOT–WELDERS

FIGURE 1

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APPLICATION

Planners are responsible for determining secondary flicker requirements according to the criteria established in this standard and the Voltage Drop and Flicker Nomographs in Design Standards 5431 and 5432. When the resulting secondary flicker is greater than the allowable limit shown on the secondary flicker chart, remedial action must be taken. Rule 2.E.1 of the Rules For The Sale Of Electric Energy requires the customer to "provide whatever corrective measures are necessary" to comply with the secondary flicker criteria. SDG&E excludes residential subdivisions from this requirement. But in all other cases, the Planner is responsible for advising the customer of his options according to SPM 272, 925 and the following:

A. Limit inrush current. The customer is to be advised of the maximum permitted inrush current which is acceptable to SDG&E. The following procedure can be used to determine the amount of inrush current reduction required to comply with this standard.

1. Calculate the flicker percentage for the customer equipment specified using nomograph on 5431/2, and transformer flicker tables on 5413.5/.6/.7.

   a. Determine the "normal" wire size needed to meet customer ampacity and volt drop requirements based on customer's demand. Using this "normal" wire size calculate the flicker % on the wire.

   b. Determine "normal" transformer size needed based on customer's demand.

2. Calculate maximum flicker percentage permitted by the secondary flicker chart on 5413.1.

3. Calculate the acceptable inrush current by dividing step 2's answer by step 1's and multiplying the result by the motor starting current found in the transformer flicker tables.

Ex: A customer wishes to install a 30 HP single elevator motor to be served underground by 3 phase, 120/208V service with 100' of cable. Assume that ampacity and voltage drop analysis has been completed and, you have selected a 75 kVA tranformer and 1 run of # 1000 kcmil cable.

Step 1: Calculate % flicker.

Refering to 5431.2, using 100' of # 1000 cable to feed a 30 HP motor, the nomograph yields a flicker of 1.5%.

From 5413.7, Table 8, the 75 kVA transformer has 4.5% flicker for a 30 HP motor.

The total flicker is 1.5% + 4.5%=6.0%

Step 2: Determine maximum permitted secondary flicker.

Consult 5413.1, the maximum permitted secondary flicker is 2.5%.

Step 3: Calculate maximum permitted inrush current:

The maximum permitted inrush current is equal to:

$$\left(\frac{\text{maximum permitted secondary flicker}}{\text{total flicker}}\right) \times \text{LRC}$$

From 5413.7, Table 8, the LRC is 481 amps. Calculating maximum permitted inrush current yields:

$$\frac{2.5\%}{6.0\%} \times 481 = 200 \text{ amps.}$$

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Conclusion:

The "normal" facilities required to serve the customer's load, based on demand, and needed to meet cable ampacity & volt drop requirements are 1 run of #1000 and a 75 KVA transformer. But the customer is installing equipment such that the "normal" facilities are not able to prevent flicker problems. Several solutions are available.

B. Solutions

Option 1. Reduce system impedance by increasing the size or shortening the length of the secondary/service wires. The customer is to pay the cost for any additional facilities beyond "normal". See Rule Interpretation E.3.6.

Option 2. Reduce system impedance by increasing the size of the transformer. The customer is to pay the cost for any additional facilities beyond "normal". See Rule Interpretation E.3.6.

Option 3. (3 phase equipment) Have the customer install an inrush limitation device, Rule 2.e.1. Some examples are:

a. Wye–Delta starter.
This device typically limits inrush current to about 33% of it's normal locked rotor current. (locked rotor current is generally about 6 times the value of the full load current).

b. Electronic Motor Controller.
This device is adjustable and can limit inrush current as low as 25% of full load current.

c. Electronic Motor Controller. (2nd type)
This device is adjustable and can limit inrush current as low as 50% of full load current. It also offers pump control to provide smooth acceleration and deceleration for centrifugal pumps.

Considerations:

- How much fusing capacity, in KVA, is remaining on the branch/system. And will additional transformer KVA surpass this remaining capacity?
- What's the potential for future growth. Will this future growth have a feeder to rely on, or is the current branch/system, with it's remaining capacity, all there is?
- Does the circuit have sufficient capacity for load growth?
- It is reasonable to provide the additional transformer KVA to be used only for motor inrush/starting?
- Larger transformers have higher no–load losses.

Recommendations

Choice #1: Provide additional secondary/service wire.

Choice #2: Provide additional 75 or 150 KVA transformer capacity.

Choice #3: Have the customer install a current inrush limiting device, or install additional transformer capacity in excess of 150 KVA. This choice is at the customer project planner's discretion and should be based on economic and or the above considerations.

Choice #4: Any combination of the above 3 choices.

General Notes

1. Transformers and secondary/service conductors may be sized for 10% secondary flicker when no incandescent lamps or sensitive electronic equipment will be powered from the serving transformer. Dedicated services to submersible pumps, wind machines, etc. may satisfy this requirement.
2. A 6% secondary flicker is specified for single–phase residential subdivisions on the secondary flicker chart. For an existing residential customer served from an existing transformer, the secondary flicker may be raised to 7% if a larger transformer would be required to meet the 6% secondary flicker limit while serving normal load.

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3. The permitted secondary frequency chart, 5413.1, is dependent on the frequency of fluctuations (per day/hour/etc), as indicated at the base of the chart. It is therefore necessary to know the number of times a motor or other equipment causing inrush will start. For multiple motors add the frequency of motor starts before using the chart.

4. The transformer flicker percentage (obtained from Tables 1 thru 8) should be based on the largest motor attached to the system, not the sum of the motors connected, unless simultaneous starting is indicated. When in doubt, regarding simultaneous starts, ask the customer or check the submitted electrical plans.

5. With multiple customers being served from the same transformer, all the customers will see the transformer flicker for the largest motor/equipment from any of the individual customers. The transformer flicker for this largest motor/equipment should be used to calculate the total flicker (transformer + secondary/service) for each of the other customers.

6. An example using the secondary flicker chart and transformer flicker tables is shown on DM 5411.3.

   The following transformer flicker tables were constructed using the equation and assumptions below:

$$V\%,\ 1Ph = \left(\frac{\text{Starting Current}}{\frac{\text{Transformer KVA}}{\text{Transformer KV}}}\right) \times (\%R\ \cos\theta + \%X\ \sin\theta)$$

$$V\%,\ 3Ph = \left(\frac{\text{Starting Current}}{\frac{\text{Transformer KVA}}{\sqrt{3} \times \text{Transformer KV}}}\right) \times (\%R\ \cos\theta + \%X\ \sin\theta)$$

   a. The motor starting current, or locked rotor current, was obtained from tables 1 and 2 of Rule 2 within SDG&E's Rules For the Sale of Electric Energy.

   b. Motor starting Power factor:
      single phase motor = 0.75 --> cosØ = 0.75, sinØ = 0.66
      three phase motor = 0.3 --> cosØ = 0.3, sinØ = 0.95

   c. Transformer resistance (R) and reactance (X) represent typical values for transformers purchased by SDG&E.

   d. Table 1 concerning the open–delta station has 58 percent of the three–phase current going to each transformer, while all the single–phase current goes to the larger transformer. The maximum 10 HP requirement on newly constructed and converted (going from overhead to underground) open–delta station applies to single–phase and three–phase motors. This is because larger single–phase motors produce an unacceptable voltage unbalance while larger three–phase motors will not operate properly due to the missing phantom phase voltage. All submersible pumps shall be served from a closed delta station.

   e. Each transformer in a closed–delta station supplies 1/3 of the three–phase current.

   f. Tables assume the transformer is fully loaded at whatever operating voltage is permitted for the transformer. Because the tables are voltage independent the locked rotor current for all permitted voltage levels is not duplicated on each table.

   g. Table 1 applies to the single–phase load attached to an open–delta station as well as the single–phase load attached to a single–phase station.

   h. The effect of air conditioning equipment on flicker can be determined from the tables by dividing the HP by 1.5 to convert to tons (Design Standard 5321).

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Table 1 – Percent Flicker on Single–Phase Transformer or Larger Transformer in Open–Delta Overhead Station

1–Phase Trans (kVA)	Single–Phase Motor (Sized in HP)												Transformer Data			
	1	1.5	2	1	1.5	2	3	4.5	5	6	7.5	10	R	X	X/R Ratio	Z%
	120V			240V												
10	2.2	3.3	4.5	1.3	1.6	2.2	3.3	5.0	5.6	6.8	8.5	10.6	1.9%	0.9%	0.5	2.1%
15	1.6	2.3	3.1	0.9	1.2	1.6	2.3	3.5	3.9	4.7	5.9	7.4	1.5%	1.5%	1.0	2.1%
25	0.9	1.4	1.8	0.5	0.7	0.9	1.4	2.0	2.3	2.8	3.4	4.3	1.5%	1.4%	0.9	2.1%
50	0.5	0.7	1.0	0.3	0.4	0.5	0.7	1.1	1.2	1.5	1.9	2.3	1.3%	1.9%	1.5	2.3%
75	0.3	0.5	0.6	0.2	0.2	0.3	0.5	0.7	0.8	0.9	1.2	1.5	1.1%	1.9%	1.7	2.2%
100	0.3	0.4	0.5	0.1	0.2	0.3	0.4	0.6	0.6	0.8	1.0	1.2	1.3%	2.0%	1.5	2.4%
Locked Rotor Current																
	46	69	92	27	34	46	69	103	115	140	175	218				

Table 2 – Percent Flicker on Either Transformer in Open–Delta Overhead Station

1–Phase Trans (kVA)	Three–Phase Motor (Sized in HP)						Transformer Data			
	3	4.5	5	6	7.5	10	R	X	X/R Ratio	Z%
10	2.2	2.9	3.1	3.6	4.3	5.5	1.9%	0.9%	0.5	2.1%
15	1.9	2.6	2.8	3.2	3.8	4.9	1.5%	1.5%	1.0	2.1%
25	1.1	1.5	1.6	1.8	2.2	2.8	1.5%	1.4%	0.9	2.1%
50	0.7	0.9	1.0	1.1	1.3	1.7	1.3%	1.9%	1.5	2.3%
75	0.4	0.6	0.6	0.7	0.9	1.1	1.1%	1.9%	1.7	2.2%
100	0.4	0.5	0.5	0.6	0.7	0.9	1.3%	2.0%	1.5	2.4%
Locked Rotor Current										
❷240V	64	85	92	106	127	162				

Table 3 – Percent Flicker on Closed–Delta or Wye Overhead Station

1–Phase Trans (kVA)	Three–Phase Motor (Sized in HP)															Transformer Data			
	3	4.5	5	6	7.5	10	15	20	25	30	40	50	75	100	150	R	X	X/R Ratio	Z%
10	1.3	1.7	1.8	2.1	2.5	3.2	4.6	5.7	7.2	8.6						1.9%	0.9%	0.5	2.1%
15	1.1	1.5	1.6	1.8	2.2	2.8	4.0	5.0	6.3	7.5	10.0					1.5%	1.5%	1.0	2.1%
25	0.6	0.8	0.9	1.0	1.3	1.6	2.3	2.9	3.6	4.3	5.7	7.2	10.7			1.5%	1.4%	0.9	2.1%
50	0.4	0.5	0.6	0.6	0.8	1.0	1.4	1.8	2.2	2.6	3.5	4.4	6.6	8.8		1.3%	1.9%	1.5	2.3%
75	0.3	0.3	0.4	0.4	0.5	0.6	0.9	1.1	1.4	1.7	2.3	2.9	4.3	5.7	8.6	1.1%	1.9%	1.7	2.2%
100	0.2	0.3	0.3	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.8	2.3	3.4	4.6	6.9	1.3%	2.0%	1.5	2.4%
Locked Rotor Current																			
❷240V	64	85	92	106	127	162	232	290	365	435	580	725	1085	1450	2170				
❷208V	71	94	102	117	140	179	257	321	404	481	641	802	1200	1603	2400				

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Table 4 – Percent Flicker on Closed Delta Overhead Station

1–Phase Trans (kVA)	Three–Phase Motor (Sized in HP)															Transformer Data			
	3	4.5	5	6	7.5	10	15	20	25	30	40	50	75	100	150	R	X	X/R Ratio	Z%
25	0.6	0.8	0.9	1.0	1.3	1.6	2.3	2.9	3.6	4.3	5.7	7.2	10.7			1.5%	1.4%	0.9	2.1%
50	0.4	0.5	0.6	0.6	0.8	1.0	1.4	1.8	2.2	2.7	3.5	4.4	6.6	8.8		1.3%	1.9%	0.5	2.3%
75	0.3	0.3	0.4	0.4	0.5	0.6	0.9	1.1	1.4	1.7	2.3	2.9	4.3	5.7	8.6	1.1%	1.9%	1.7	2.2%
Locked Rotor Current @480V	32	43	46	53	63.5	81	116	145	183	218	290	363	543	725	1085				

Table 5 – Percent Flicker on Single–Phase Padmount or Larger Transformer in Open–Delta Padmounted Station

1–Phase Trans (kVA)	Single–Phase Motor (Sized in HP)												Transformer Data			
	1	1.5	2	1	1.5	2	3	4.5	5	6	7.5	10	R	X	X/R Ratio	Z%
	120V			240V												
15	1.5	2.3	3.0	0.9	1.1	1.5	2.3	3.4	3.8	4.6	5.8	7.2	1.7%	1.2%	0.7	2.1%
25	0.9	1.3	1.7	0.5	0.6	0.9	1.3	2.0	2.2	2.7	3.3	4.1	1.6%	1.2%	0.8	2.0%
50	0.5	0.7	0.9	0.3	0.3	0.5	0.7	1.0	1.2	1.4	1.8	2.2	1.3%	1.7%	1.3	2.1%
75	0.3	0.4	0.6	0.2	0.2	0.3	0.4	0.6	0.7	0.9	1.1	1.4	1.1%	1.8%	1.7	2.0%
100	0.2	0.3	0.5	0.1	0.2	0.2	0.3	0.5	0.6	0.7	0.9	1.1	1.1%	1.9%	1.7	2.2%
Locked Rotor Current	46	69	92	27	34	46	69	103	115	140	175	218				

Table 6 – Percent Flicker on Either Transformer in Open–Delta Padmounted Station

1–Phase Trans (kVA)	Three–Phase Motor (Sized in HP)						Transformer Data			
	3	4.5	5	6	7.5	10	R	X	X/R Ratio	Z%
	240V									
15	1.7	2.2	2.4	2.8	3.4	4.3	1.7%	1.2%	0.7	2.1%
25	1.0	1.3	1.4	1.6	2.0	2.5	1.6%	1.2%	0.8	2.0%
50	0.6	0.8	0.9	1.0	1.2	1.6	1.3%	1.7%	1.3	2.1%
75	0.4	0.5	0.6	0.7	0.8	1.0	1.1%	1.8%	1.7	2.0%
100	0.3	0.4	0.5	0.5	0.6	0.8	1.1%	1.9%	1.7	2.2%
Locked Rotor Current @240V	64	85	92	106	127	162				

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Table 7 - Percent Flicker on Closed-Delta Padmounted Transformer Station

1-Phase Trans (kVA)	Three-Phase Motor (Sized in HP)																		Transformer Data			
	3	4.5	5	6	7.5	10	15	20	25	30	40	50	60	75	100	125	150	200	R	X	X/R Ratio	Z%
15	.9	1.2	1.3	1.5	1.8	2.2	3.2	4.0	5.1	6.0	8.0								1.2%	1.2%	1.0	1.7%
25	0.5	0.7	0.8	0.9	1.1	1.4	2.0	2.5	3.1	3.7	4.9	6.1							1.3%	1.2%	0.9	1.8%
50	0.4	0.5	0.5	0.6	0.7	0.9	1.3	1.6	2.0	2.4	3.2	4.0	4.8	5.9	7.9				1.2%	1.7%	1.4	2.1%
75	0.2	0.3	0.4	0.4	0.5	0.6	0.9	1.1	1.4	1.7	2.2	2.8	3.3	4.1	5.6	6.9	8.3		1.2%	1.8%	1.5	2.2%
100	0.2	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.1	1.5	1.9	2.2	2.8	3.7	4.7	5.6	7.4	1.1%	1.6%	1.5	1.9%
Locked Rotor Current @240V	32	85	92	106	127	162	232	290	365	435	580	725	870	1085	1450	1815	2170	2900				

Table 8 - Percent Flicker on Three-Phase Padmounted Transformer - 208 V

3-Phase Trans (kVA)	Three-Phase Motor (Sized in HP)																		Transformer Data			
	3	4.5	5	6	7.5	10	15	20	25	30	40	50	60	75	100	125	150	200	R	X	X/R Ratio	Z%
45	1.4	1.8	1.9	2.2	2.7	3.4	4.9	6.1	7.7	9.1									1.9%	1.9%	1.0	2.7%
75	0.5	0.7	0.7	0.8	1.0	1.3	1.8	2.3	2.9	3.4	4.6	5.7	6.9	8.6					1.0%	1.3%	1.2	1.6%
150	0.2	0.3	0.3	0.4	0.5	0.6	0.9	1.1	1.4	1.6	2.1	2.7	3.2	4.0	5.4	6.7	8.0		1.0%	1.2%	1.2	1.5%
225	0.2	0.3	0.3	0.3	0.4	0.5	0.7	0.9	1.2	1.4	1.9	2.3	2.8	3.5	4.7	5.8	7.0	9.3	0.9%	1.6%	1.8	1.9%
300	0.4	0.5	0.5	0.6	0.7	0.9	1.3	1.7	2.1	2.5	3.3	4.2	5.0	6.2	8.3	10.4	12.5	16.7	1.0%	4.2%	4.2	4.4%
500	0.2	0.3	0.3	0.4	0.5	0.6	0.9	1.1	1.3	1.6	2.1	2.7	3.2	4.0	5.3	6.7	8.0	10.7	1.0%	4.5%	4.5	4.6%
750	0.2	0.3	0.3	0.3	0.4	0.5	0.7	0.9	1.1	1.3	1.7	2.1	2.6	3.2	4.3	5.4	6.4	8.6	0.9%	5.6%	6.3	5.6%
1000	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.3	1.6	1.9	2.4	3.2	4.0	4.8	6.4	0.8%	5.6%	7.3	5.7%
1500	0.1	0.1	0.1	0.2	0.2	0.2	0.4	0.4	0.6	0.7	0.9	1.1	1.3	1.6	2.2	2.8	3.3	4.4	1.0%	5.7%	5.9	5.8%
Locked Rotor Current @208V	71	94	102	117	140	179	257	321	404	481	641	802	962	1200	1603	2007	2400	3207				

Table 9 - Percent Flicker on Three-Phase Padmounted Transformer - 480 V

3-Phase Trans (kVA)	Three-Phase Motor (Sized in HP)																									Transformer Data			
	3	4.5	5	6	7.5	10	15	20	25	30	40	50	60	75	100	125	150	200	250	300	350	400	450	500	R	X	X/R Ratio	Z%
75	0.7	0.9	1.0	1.1	1.3	1.7	2.4	3.0	3.8	4.5	6.0	7.5	9.0	11.0											1.4%	1.5%	1.1	2.1%
150	0.6	0.8	0.8	1.0	1.2	1.5	2.1	2.6	3.3	4.0	5.3	6.6	7.9	9.9	13.0	17.0	19.8								1.0%	3.2%	3.2	3.3%
225	0.2	0.2	0.3	0.3	0.4	0.4	0.6	0.8	1.0	1.2	1.6	2.0	2.4	3.0	4.0	5.0	6.0	8.0							0.8%	1.3%	1.6	1.6%
300	0.1	0.2	0.2	0.2	0.2	0.3	0.5	0.6	0.7	0.9	1.1	1.4	1.7	2.1	2.9	3.6	4.3	5.7	7.2	8.7					0.9%	1.2%	1.4	1.5%
500	0.2	0.2	0.2	0.3	0.3	0.4	0.6	0.7	0.9	1.0	1.4	1.7	2.1	2.6	3.5	4.4	5.2	7.0	8.8	10.6	12.3	14.0	15.6	17.5	0.8%	2.8%	3.7	2.9%
750	0.2	0.3	0.3	0.3	0.4	0.5	0.7	0.9	1.1	1.3	1.8	2.2	2.7	3.3	4.5	5.6	6.7	8.9	11.3	13.6	15.7	17.9	20.0	22.4	0.8%	5.6%	7.2	5.7%
1000	0.2	0.2	0.2	0.2	0.3	0.4	0.5	0.7	0.9	1.0	1.3	1.7	2.0	2.5	3.4	4.2	5.0	6.7	8.5	10.2	11.8	13.5	15.1	16.9	0.8%	5.6%	7.3	5.7%
1500	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.9	1.1	1.4	1.7	2.3	2.8	3.4	4.5	5.7	6.9	7.9	9.0	10.1	11.3	0.6%	5.7%	9.5	5.8%
2000	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.7	2.1	2.5	3.4	4.2	5.1	5.9	6.7	7.5	8.4	0.7%	5.7%	8.4	5.7%
2500	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.7	0.8	1.0	1.3	1.7	2.0	2.7	3.4	4.1	4.7	5.4	6.0	6.8	0.6%	5.7%	10.0	5.7%
3000	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.5	0.6	0.8	1.1	1.3	1.6	2.1	2.7	3.3	3.8	4.3	4.8	5.4	0.6%	5.4%	8.5	5.4%
Locked Rotor Current @480V	32	43	46	53	63.5	81	116	145	183	218	290	363	435	543	725	908	1085	1450	1825	2200	2550	2900	3250	3635				

SCOPE

All Distributed Energy Resource (DER) facilities shall comply with the flicker power quality requirements in the latest versions of IEEE 1547 and Rule 21 Generation Interconnection requirements.

DEFINITIONS

- DERs - Small-scale generation resources, ≤20 MW, that are interconnected to the distribution electric grid. Large-scale generation resources are thereby defined as >20 MW which are connected at the transmission level (69 kV and above). SDG&E completes system impact studies for DER facilities of 30 kW and larger. DERs include, but are not limited to generators, solar arrays, wind turbines, and batteries.
- Flicker – The subjective perception of varying brightness, resulting from fluctuations in voltage over a period of time.

CRITERIA

A. SDG&E requires that the calculated maximum flicker induced by the DER shall not exceed 3% of the nominal voltage measured at the point of common coupling (PCC) unless the Company establishes alternate limits in special situations that include, but are not limited to, tap changer and capacitor operation and the type and number of customers on the circuit.

B. When considering impacts of flicker, the rate of change for DER output is assumed to be instant, from full 100 percent to 5 percent output, and vice versa.

C. Simultaneous output changes on other DER sites on the circuit may be considered for the analysis if they are the same type since a common event could affect more than one site. If the circuit occupies a large geographic area, the Company may consider the variability of DER output under various conditions.

D. **DER owner requirements**: Harmonic current injection into the Electric Power System (EPS) at the Point of Common Coupling (PCC) shall be consistent with limits established by Rule 21.

E. The interconnection of the DER facility shall not increase the potential for ferroresonance in the EPS, especially where the electrical system is ungrounded or where it is effectively ungrounded due to high-ground impedances.

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B							E						
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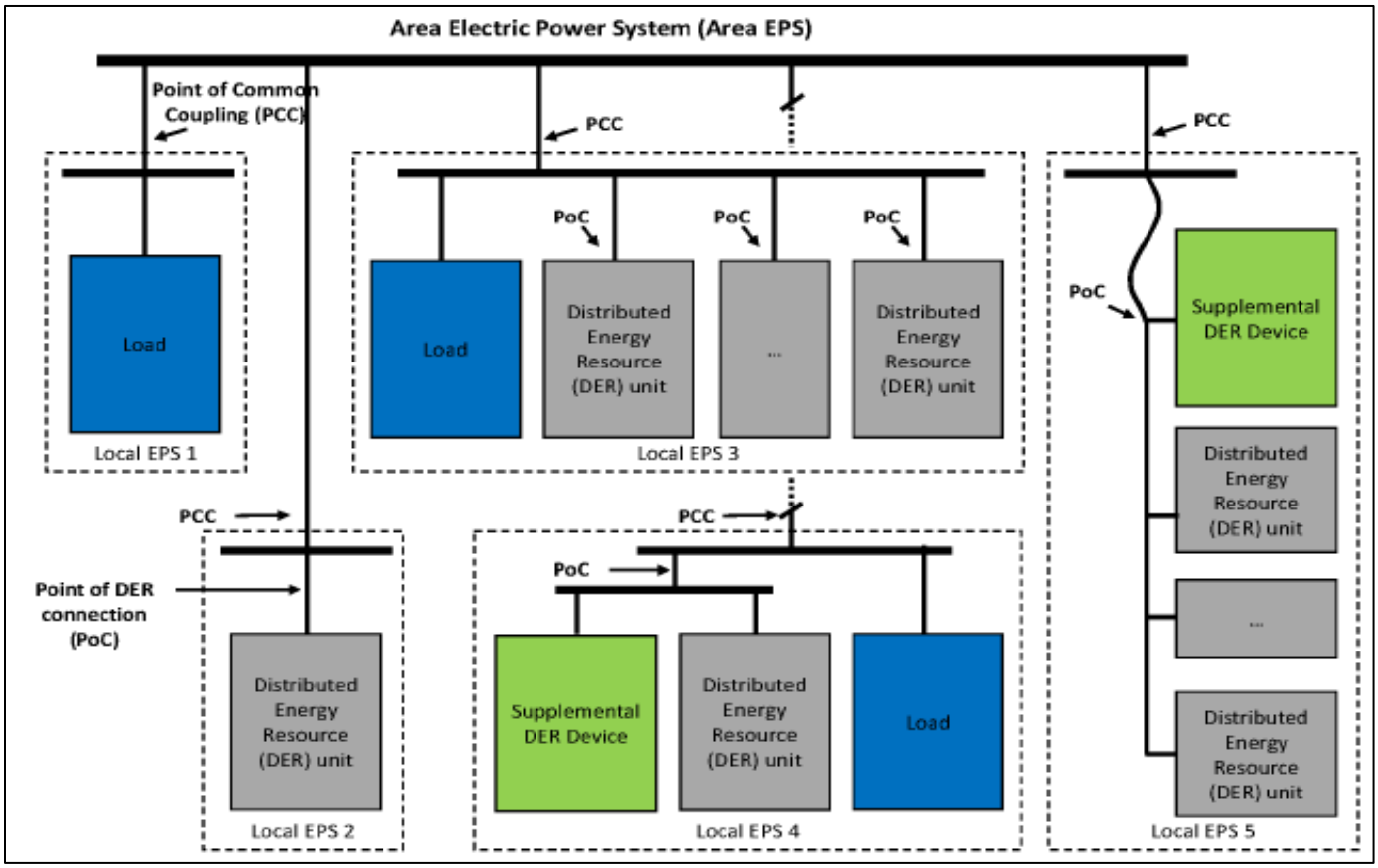


Figure 1
IEEE Std 1547-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces – The Requirements of IEEE 1547 shall be met regardless of the location of the DER Devices within the Local EPS. These relationships are shown in Figure 1

NOTES

I. The example of Local EPS 1 includes only load. Any requirements for this Local EPS are outside the scope of this standard.

II. The example of Local EPS 2 includes only DER. Depending on the DER rating, requirements of this standard apply either at the PCC or the PoC. The DER unit, in this example, is able to meet requirements at its terminals without any supplemental DER device; the PoC coincides with the DER unit's terminals.

III. The example of Local EPS 3 includes two DER units and load. Depending on the DER aggregate DER rating and the percent of average load demand, requirements of this standard apply either at the PCC or the PoC. If the two (or more) DER units are able to meet requirements at their terminals without any supplemental DER device, then the PoC coincides with the DER units' terminals and there are two (or more) PoCs.

IV. The example of Local EPS 4 includes a DER unit, a supplemental DER device, and load. Depending on the DER unit's rating and the percent of average load demand, requirements of this standard apply either at the PCC or the PoC. If the DER unit is not able to meet requirements at its terminals without any supplemental DER device, then the single PoC is the point where the requirements within this standard are required by the DER unit in conjunction with the supplemental DER; note if load is present exclude from the PoC and only include as part of the Local EPS PCC.

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B							E						
A	Original Issue	YZZ	KNM	FRC	KRG	01/03/2025	D						

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V. The example of Local EPS 5 includes two (or more) DER units and a supplemental DER device but no load. Depending on the aggregate DER units' rating, requirements of this standard apply either at the PCC or the PoC. As indicated by the curved line, the PCC and PoC may be located well apart from each other. The two (or more) DER units are not able to meet requirements at their terminals without any supplemental DER device; the PoC is the point where the requirements of this standard are met by two (or more) DER units in conjunction with the supplemental DER device exclusive of any load, if present, in the respective part of the Local EPS.

> **7.2 Limitation of voltage fluctuations induced by the DER**
>
> **7.2.1 General**
>
> The DER shall not create unacceptable rapid voltage changes or flicker at the point of common coupling (PCC).

Figure 2
IEEE Std 1547-2018 – IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

> **4. General considerations for DR impact studies**
>
> An impact study identifies potential problems and allows the Area EPS operator to determine the modifications to the Area EPS facilities that could correct the problems identified in the impact study. In some cases, the Area EPS operator may also prepare system-level studies to assess the cumulative or combined impacts of multiple DR interconnections.
>
> The impacts of the interconnection of DR at a particular location within the Area EPS depend on the specific characteristics of the DR, the proposed interconnection, the proposed point of interconnection within the Area EPS, and the specific characteristics of the Area EPS itself. The bigger the DR, the more effect it is likely to have on the distribution system. For particular types of DR, such as inverter-based photovoltaics (PV) or synchronous generation, there are technology-specific considerations that determine the impact of the DR on the Area EPS. Characteristics of the DR that derive from its source of primary energy, such as its variability, its predictability of operation under different circuit or EPS operating conditions, and its dispatchability (or the ability to alter output as needed), also help determine the impact of the DR on the EPS. Clause 5 provides additional discussion of attributes of the DR that affect interconnection.

Figure 3
IEEE Std 1547.7-2013 – IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Integration

VI. The interconnection of the DER facility shall not cause temporary under-voltages or over-voltages as determined by the Company when studying the proposed interconnection.

VII. The steps to follow for a voltage flicker study are:

VIII. With all DER online (projected and existing at 100% capacity) - a load flow is run, and all node voltages for all phases are registered for the initial condition.

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1. Voltage control equipment is locked in their resulting positions or states (LTCs, VRs, and voltage-controlled capacitors), and all Distributed Generation (DG) capacity is reduced to 5%.
2. A load flow is run, and all node voltages for all phases are registered for the final condition.
3. Voltage percent variation is computed for every node using $\frac{|V_f - V_i|}{V_i} \times 100$

   Where V_i Initial Voltage
   V_f Final Voltage

4. The maximum allowable voltage percent variation (flicker) shall not exceed 3%.

IX. If the voltage flicker is greater than the maximum allowable, try operating the projected DG at the off-unity power factor. If this method doesn't work, try downsizing DG, circuit reconfiguration, or reconductoring. Mitigations for flicker can include dynamic volt-var reactive (D-VAR) and static synchronous compensator (STATCOM) or distribution (D-STATCOM) using IEEE Std 1623-2020 with guidelines on the preparation of a functional specification for a shunt device.

ATTENTION: For cases with batteries – if the application includes Battery Energy Storage Systems (BESS), a narrative on the battery operation should be available that states if the battery is expected to charge from the grid or not. If the narrative is not supplied, request it from the client. Using basic BESS operating assumptions, the BESS will compensate for DG variations for flicker and tap changes analyses. One should also test the battery charging from the grid during peak load (and during light load discharging, if applicable) unless the narrative says the BESS won't charge from the grid. If BESS charging produces problems, a Type 32 - Directional Power / Reverse Power Function relay can be used as a mitigation to limit the amount of power the battery takes from the system.

RULE 21 Sheet 134

GENERATING FACILITY INTERCONNECTIONS

Hh. Smart Inverter Generating Facility Design and Operating Requirements (Continued)

2. Prevention of Interference (Continued)

c. Paralleling

The Smart Inverter shall parallel with Distribution Provider's Distribution or Transmission System without causing a voltage fluctuation at the PCC greater than plus/minus 5% of the prevailing voltage level of Distribution Provider's Distribution or Transmission System at the PCC, and meet the flicker requirements of Section H.2.d. Section L, Certification and Testing Criteria, provides technology-specific tests for evaluating the paralleling Function. (IEEE 1547-4.1.3)

d. Flicker

The Smart Inverter shall not create objectionable flicker for other customers on Distribution Provider's Distribution or Transmission System. To minimize the adverse voltage effects experienced by other customers (IEEE 1547-4.3.2), flicker at the PCC caused by the Generating Facility should not exceed the limits defined by the "Maximum Borderline of Irritation Curve" identified in IEEE 519-1992 (IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems, IEEE STD 519-1992). This requirement is necessary to minimize the adverse voltage affects experienced by other Customers on Distribution Provider's Distribution or Transmission System.

Figure 4
SDG&E/Rule 21/Generating Facility Interconnections (05-29-2022)

X. The GE flicker curve (Figure 5) is referenced in IEEE 1453-2015. This IEEE standard is used as a reference many times in SDG&E Rule 21 – Generating Facility Interconnections.

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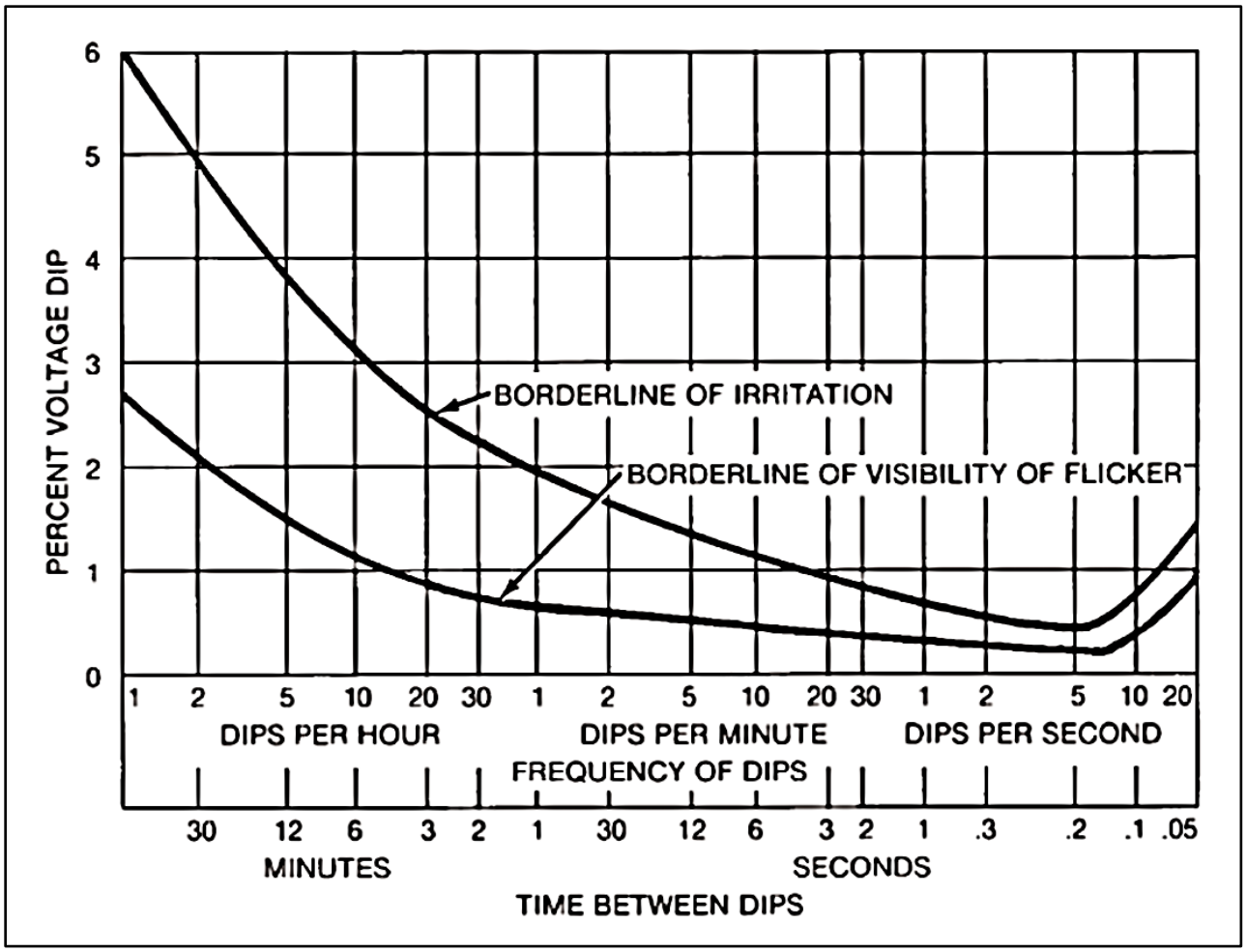


Figure 5
GE Flicker Curve from IEEE Std 1453-2022 – IEEE Standard for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems

ATTENTION: All information within boxes is directly from IEEE Std 1547 or IEEE Std 1453.

REFERENCES

I. IEEE Std 1547-2018, IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

II. IEEE Std 1547.7-2013, IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Integration

III. IEEE Std 1453-2022, IEEE 1453-2022 IEEE Standard for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems

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SCOPE

This standard defines permissible levels of voltage flicker on the primary distribution system. It also provides the analytical tools necessary to calculate motor starting inrush kVA. The subject of secondary flicker is discussed in Design Standard 5413.

PURPOSE

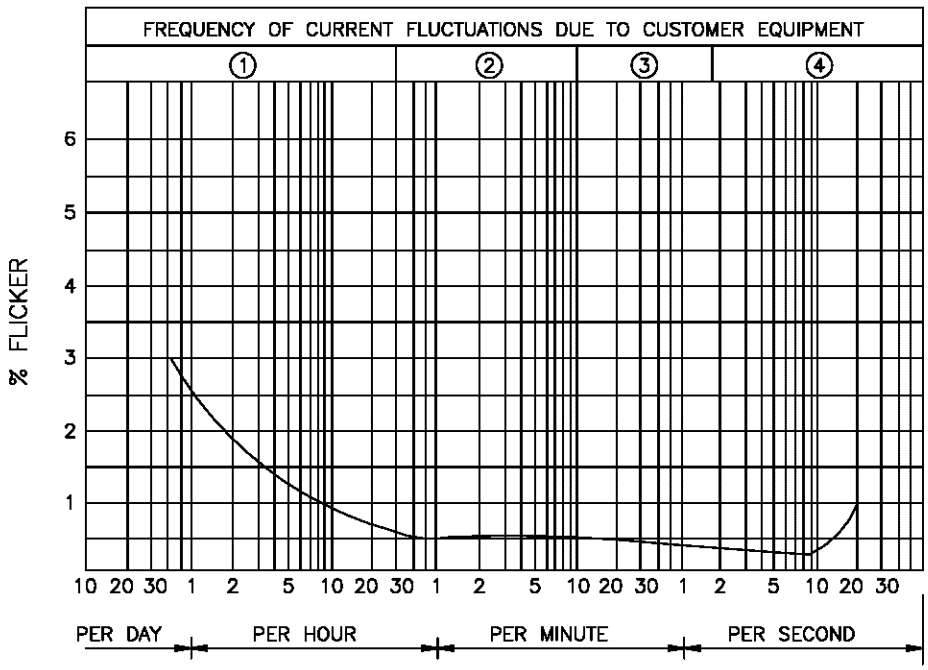
District Engineering personnel should use this standard as a reference when dealing with customer inquiries. It also provides a basis for specifying equipment operating limitations necessary to avoid customer complaints due to primary voltage flicker.

DEFINITIONS

Primary System Voltage Flicker, also known as primary flicker, is defined at SDG&E as the percentage voltage fluctuation from the distribution substation to the customer's primary metering station or primary terminals of the distribution transformer due to the operation of cyclic loads or motor starting.

CRITERIA

Sudden reductions in system voltage or rapid fluctuations in voltage effect the lumen output of lamps. This variation in light output is referred to as flicker. The acceptable amount of primary system voltage fluctuation as a function of frequency is illustrated in Figure 1. Primary system flicker limitations are more restrictive than secondary system limitations due to the larger number of affected customers, and the relatively high cost of eliminating a primary flicker problem.



③ ARC FURNACES
FLASHING SIGNS
ARC–WELDERS
MANUAL SPOT–WELDERS
DROP HAMMERS
SAWS
GROUP ELEVATORS

④ RECIPROCATING PUMPS
AUTOMATIC SPOT–WELDERS

① HOUSE PUMPS
SUMP PUMPS
COMPRESSORS
AIR CONDITIONING EQUIP.
THEATRICAL LIGHTING
DOMESTIC REFRIGERATORS
OIL BURNERS
COMPRESSORS

② SINGLE ELEVATOR
HOISTS
CRANES
Y–DELTA CHANGES ON
ELEVATOR–MOTOR–GENERATOR
X–RAY EQUIPMENT

FIGURE 1

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REVISION DATE 1–1–91 APPD CVN /	SDG&E DISTRIBUTION DESIGN MANUAL PRIMARY SYSTEM VOLTAGE FLICKER LIMIT CALCULATION	5421.1

The 3 percent maximum permitted primary flicker applies to all equipment connected to the distribution system, including switched capacitors. Generally, motor start analysis is performed to determine the extent to which starting inrush current must be restricted to prevent exceeding the primary flicker limitations established in Figure 1. Across-the-line starting of a motor may result in initial currents of 6 times the motor's rated full load current. However, motors and/or motor control centers may be designed to limit the starting current significantly. Other equipment such as impulse loads, arc furnaces, and customer owned generators can also produce an unacceptable level of primary flicker.

The district engineer must determine the inrush limitations according to Equation 1. The customer applying for service is to be supplied with the inrush limitation along with the following:

1. Motor kVA and voltage
2. Assumed starting intervals (once per hour, etc.)
3. Assumed starting power factor

$$\text{Inrush kVA} = \frac{(\%\text{flicker})\ (\text{base kVA})}{100\ (R\cos\emptyset + X\sin\emptyset)} \qquad \text{Equation 1}$$

Where:

1. % flicker – Maximum permissible primary flicker for a specified starting interval (Figure 1).
2. R,X = total system Resistance and Reactance (substation bus impedance plus distribution line impedance on a comon base).
3. $\emptyset$ = angle of motor starting power factor from the table below or as supplied by the customer.

The following motor starting power factor table should be used when exact motor starting characteristics cannot be supplied by the customer:

MOTOR – HP	COS $\emptyset$	SIN $\emptyset$
30	.419	.908
40	.390	.921
50	.382	.924
60	.349	.937
75	.330	.944
100	.309	.951
150	.280	.960
200	.251	.968
250	.231	.973
300	.219	.976
400	.199	.980
500	.178	.984
600	.167	.986
700	.167	.986
800	.167	.986
900	.161	.987
1000	.148	.989
1200	.148	.989
1500	.148	.989

EXAMPLE

An Electric Service Load Study indicates that a small manufacturing plant intends to attach a 200 hp motor to the 12kV system supplied by a 20 Mva substation transformer. The motor starts once every two minutes. The address and serving circuit are also specified. Using this information, the following steps should be taken:

1. From the Primary Voltage Flicker Chart (Page 5421.1) the flicker limitation is found to be 0.6 percent for a load starting 30 times per hour.

2. The total impedance (distribution line and 12kV bus) to the point of service is determined from the PSSU program to be:

   $Z_{line} = 2.015 + j1.156$ p.u. on 100 Mva base

3. The starting power factor was not provided by the customer so it is necessary to use the information for a 200 HP motor from the above table:

   $\cos\phi = 0.251$, $\sin\phi = 0.968$

4. The inrush kVA is calculated using Equation 1 as follows:

$$KVA_{inrush} = \frac{(0.6)(100{,}000)}{100\ [(2.015)(0.251) + (1.156)(0.968)]} = 369 \text{ kVA}$$

5. The customer is provided the following:

   Maximum Inrush = 369 kVA at 208 volts

   Starts Per Hour = 30

   Starting PF = 0.251

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SCOPE

This standard establishes the percentage voltage drop at various transformer load percentages.

SINGLE PHASE POLEMOUNT

Transformer Loading	Transformer Size						
	10 kVA	15 kVA	25 kVA	50 kVA	75 kVA	100 kVA	167kVA
50%	1.1	1.0	0.8	0.9	0.8	0.8	0.9
60%	1.3	1.2	1.0	1.1	1.0	1.0	1.0
70%	1.5	1.4	1.2	1.2	1.2	1.2	1.2
80%	1.7	1.6	1.4	1.4	1.4	1.3	1.4
90%	1.9	1.8	1.6	1.6	1.5	1.5	1.5
100%	2.1	2.0	1.7	1.8	1.7	1.7	1.7
110%	2.3	2.2	1.9	1.9	1.9	1.8	1.9
120%	2.5	2.4	2.0	2.1	2.0	2.0	2.1
130%	2.7	2.6	2.2	2.3	2.2	2.2	2.2
140%	2.9	2.8	2.4	2.5	2.4	2.3	2.4
150%	3.2	3.0	2.6	2.6	2.5	2.5	2.6
160%	3.4	3.2	2.7	2.8	2.7	2.7	2.7
170%	3.6	3.4	2.9	3.0	2.9	2.8	2.9

SINGLE PHASE PADMOUNT

Transformer Loading	Transformer Size					
	15 kVA	25 kVA	50 kVA	75 kVA	100 kVA	167 kVA
50%	1.1	0.8	0.9	0.9	0.8	0.8
60%	1.3	1.0	1.1	1.0	1.0	1.0
70%	1.5	1.1	1.2	1.2	1.2	1.2
80%	1.7	1.3	1.4	1.4	1.3	1.3
90%	1.9	1.4	1.6	1.6	1.5	1.5
100%	2.1	1.6	1.8	1.7	1.7	1.7
110%	2.3	1.8	1.9	1.9	1.8	1.8
120%	2.5	1.9	2.1	2.1	2.0	2.0
130%	2.7	2.1	2.3	2.2	2.2	2.2
140%	2.9	2.2	2.5	2.4	2.4	2.3
150%	3.2	2.4	2.6	2.6	2.5	2.5
160%	3.4	2.6	2.8	2.8	2.7	2.7
170%	3.6	2.7	3.0	2.9	2.9	2.8

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

TRANSFORMER PERCENTAGE VOLTAGE DROP

DM5425.1

THREE PHASE PADMOUNT – 120/208V

Transformer Loading	Transformer Size								
	45 kVA	75 kVA	150 kVA	225 kVA	300 kVA	500 kVA	750 KVA	1000 kVA	1500kVA
50%	1.3	1.2	1.3	0.8	1.3	1.6	1.8	1.8	1.8
60%	1.6	1.5	1.5	1.0	1.6	1.9	2.2	2.1	2.2
70%	1.8	1.7	1.8	1.1	1.8	2.2	2.5	2.5	2.6
80%	2.1	2.0	2.1	1.3	2.1	2.5	2.9	2.9	2.9
90%	2.3	2.2	2.3	1.4	2.3	2.8	3.3	3.2	3.3
100%	2.6	2.4	2.6	1.6	2.6	3.1	3.6	3.6	3.7
110%	2.9	2.7	2.8	1.8	2.8	3.4	4.0	3.9	4.0
120%	3.1	2.9	3.1	1.9	3.1	3.7	4.3	4.3	4.4
130%	3.4	3.2	3.4	2.1	3.4	4.0	4.7	4.6	4.8
140%	3.6	3.4	3.6	2.3	3.6	4.4	5.1	5.0	5.1
150%	3.9	3.7	3.9	2.4	3.9	5.0	5.4	5.4	5.5

THREE PHASE PADMOUNT – 277/480Y

Transformer Loading	Transformer Size										
	75 kVA	150 kVA	225 kVA	300 kVA	500 kVA	750 kVA	1000 kVA	1500 kVA	2000 kVA	2500 kVA	3000 kVA
50%	1.0	1.2	0.7	1.3	1.3	1.8	1.8	1.8	1.8	1.7	1.8
60%	1.2	1.5	0.8	1.6	1.5	2.2	2.1	2.1	2.1	2.1	2.1
70%	1.4	1.7	1.0	1.8	1.8	2.5	2.5	2.5	2.5	2.4	2.5
80%	1.6	2.0	1.1	2.1	2.0	2.9	2.8	2.8	2.8	2.8	2.8
90%	1.8	2.2	1.2	2.4	2.3	3.2	3.2	3.2	3.2	3.1	3.2
100%	2.0	2.5	1.4	2.6	2.5	3.6	3.5	3.5	3.5	3.5	3.5
110%	2.2	2.7	1.5	2.9	2.8	4.0	3.9	3.9	3.9	3.8	3.9
120%	2.4	2.9	1.6	3.1	3.0	4.3	4.2	4.2	4.2	4.2	4.2
130%	2.6	3.2	1.8	3.4	3.3	4.7	4.6	4.6	4.6	4.5	4.6
140%	2.8	3.4	1.9	3.7	3.5	5.0	4.9	5.0	4.9	4.9	4.9
150%	3.0	3.7	2.0	3.9	3.8	5.4	5.3	5.3	5.3	5.2	5.3

Note: Single phase values assume power factor of 0.9, and three phase values assume power factor of 0.85.

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5500
CONDUCTOR
AMPACITIES

5500
CONDUCTOR
AMPACITIES

PAGE	SUBJECT
5521	FEEDER CABLE AMPACITIES BASED ON THERMAL LOADING LIMITS

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A	Original	–	–	JCE	VCR	03/01/2002	D						

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SCOPE:

This standard provides a graphical methodology for determining normal and emergency underground cable ampacity ratings dependent on system characteristics. The graphs provide the cable rating of the underground feeder in question when the loads in the neighboring feeders are given. A computer program is available that will provide more precise cable ampacity calculations. A guide to using this program is described in Design Standard 5522.

Note: Refer to Design Standard 6241 for primary conductor economic loading limits.

DEFINITIONS

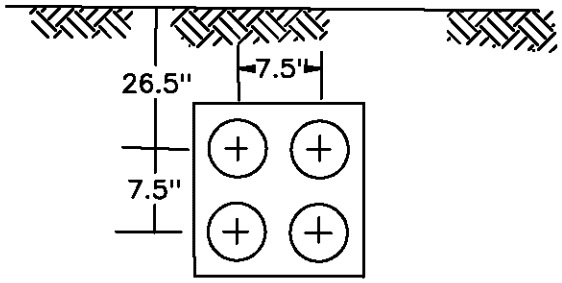
Circuit in Question – the circuit with the desired ampacity rating.

Neighboring Circuit(s) – all circuits in the duct bank other than the one in question.

Emergency Cable Ampacity Rating – elevated cable rating assuming load will be returned to normal within 12 hours.

ASSUMPTIONS

–Position with respect to earth



- Conduit size = 5 inches
- S/C = 0.100 (SEE 5522.2)
- Soil Resistivity = 120° C–cm/W
- Soil Temperature = 25° C
- Concrete Encased Conduit
- Concrete Resistivity = 85° C cm/W
- Load Factor = 0.6
- Cable Temp = 90° C

Results were obtained by running the Underground Cable Ampacity Program (EE321) and using the above assumptions. For a more detailed description of this program see Design Standard 5522.

(1) If any of the neighboring circuits have a higher loading than listed below, use the computer program to determine allowable cable ampacity. Do not use the Cable Ampacity Graphs.

TABLE 1 *

	Aluminum Cable			Copper Cable	
# Circuits in Bank	1000 kcmil	750 kcmil	350 kcmil	500 kcmil	#4/0 Cable
2	580 amps	500 amps	320 amps	450 amps	275 amps
3	530 amps	455 amps	300 amps	410 amps	255 amps
4	490 amps	425 amps	280 amps	390 amps	240 amps

* Ampacity values provided are per circuit

(2) Are all the conductors in the bank the same size and type?

The graphs were made assuming that each circuit had the same size and type conductor as the circuit in question. If one or more circuits are not the same size or type, multiply the load in those circuits by their respective correction factors as listed in table 2, and use these values in the weighted average calculation.

TABLE 2

Convert to	From	Multiply by
#4/0 CU	500 kcmil CU	0.654
350 kcmil AL	750 kcmil AL	0.685
350 kcmil AL	1000 kcmil AL	0.621
500 kcmil CU	#4/0 CU	1.54
750 kcmil AL	1000 kcmil AL	0.862
750 kcmil AL	350 kcmil AL	1.54
1000 kcmil AL	350 kcmil AL	1.78
1000 kcmil AL	750 kcmil AL	1.16

Note: The development of factors to convert from AL to CU and vice–versa was found to be impractical. Use the computer program whenever CU and AL are used together.

(3) Are the currents in the neighboring circuits equal to each other? (Not applicable if there is only one neighboring circuit).

If the load in the neighboring circuits is similar (within approximately 10 percent of each other), use the highest neighboring circuit load.

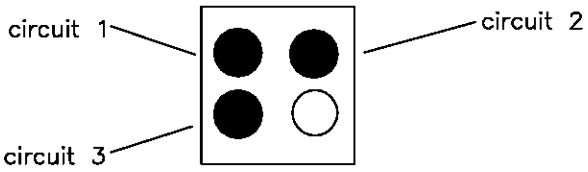
For more accurate results of any combination of loads it is better to use a weighted average of neighboring circuit loads.

For 2 neighboring circuits: Weighted Average = $\left[\frac{I_1^4 + I_2^4}{2}\right]^{1/4}$

For 3 neighboring circuits: Weighted Average = $\left[\frac{I_1^4 + I_2^4 + I_3^4}{3}\right]^{1/4}$

EXAMPLE 1

I_1 = 400 A, 1000 kcmil AL I_2 = 400 A, 1000 kcmil AL I_3 = ?, 1000 kcmil AL



FIND – Ampacity and emergency rating of circuit 3.

SOLUTION – From Table 1 on page 5521.1 we see that for a 1000 kcmil AL cable in a system with 3 circuits, the maximum allowable load is 530 amps. Therefore, for a neighboring circuit load of 400 amps, the graphs may be used to find a rating for the circuit in question (5521.6 – 3 circuits).

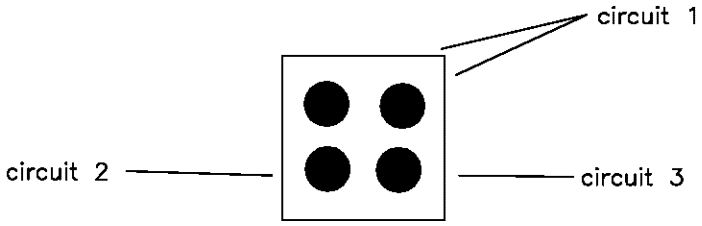
Load in neighboring circuits = 400 A
Ampacity of circuit in question = 570 A
Emergency rating = 650 A

EXAMPLE 2

I_1= 850 A
Twinned Circuit
1000 kcmil AL

I_2= 200A
750 kcmil

I_3= ?
750 kcmil



FIND – Ampacity and emergency rating of circuit 4

SOLUTION

- Assume twinned circuit is two separate circuits of 425 A each.
- Table 1 on page 5521.1 indicates that 425 A in 1000 kcmil AL and 200 A in 750 kcmil AL is less or equal to program assumptions given by table I and, therefore, the graphs may be used.

Converting neighboring conductors:

Using Table 2:

To convert to 750 kcmil cable from 1000 kcmil cable, multiply the load in the 750 kcmil cable by 0.862

I_{1000} = 425 A
I_{1000} (simulated 750) = (425 x 0.862) = 366 A

This means that 425 A in 1000 kcmil AL supplies as much heat as 366 A in 750 kcmil AL.

The neighboring circuits now have same size conductors as the circuit in question.

– Find weighted average of loads in neighboring circuits:

$$\text{Weighted Average} = \left[\frac{I_1^4 + I_2^4 + I_3^4}{3}\right]^{1/4}$$

$$= \left[\frac{366^4 + 366^4 + 200^4}{3}\right]^{1/4}$$

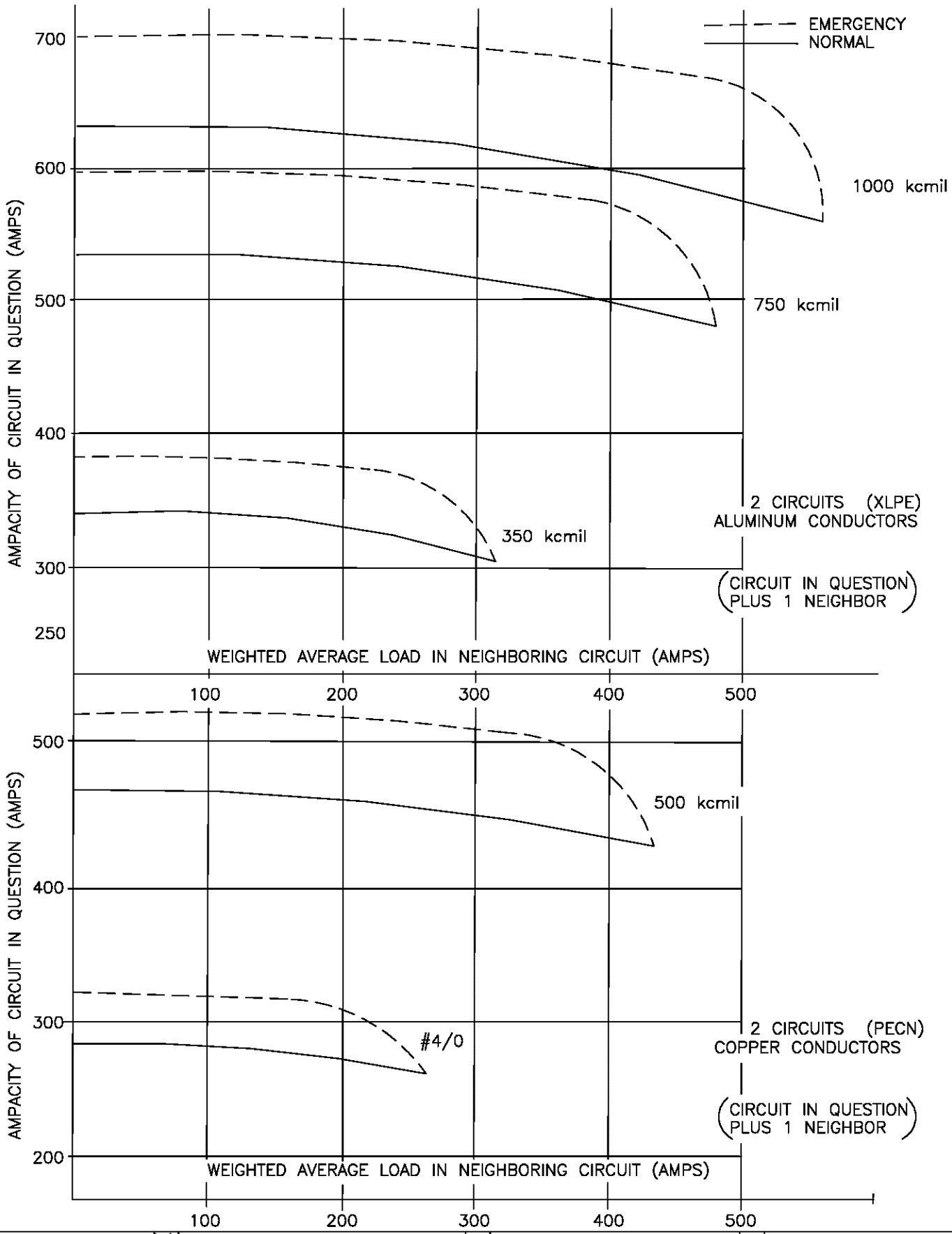
$$= 334 \text{ Amps}$$

Using the 4 Circuits – Aluminum Conductors Graph:

Ampacity of circuit 3 = 465 A
Emergency rating = 545 A

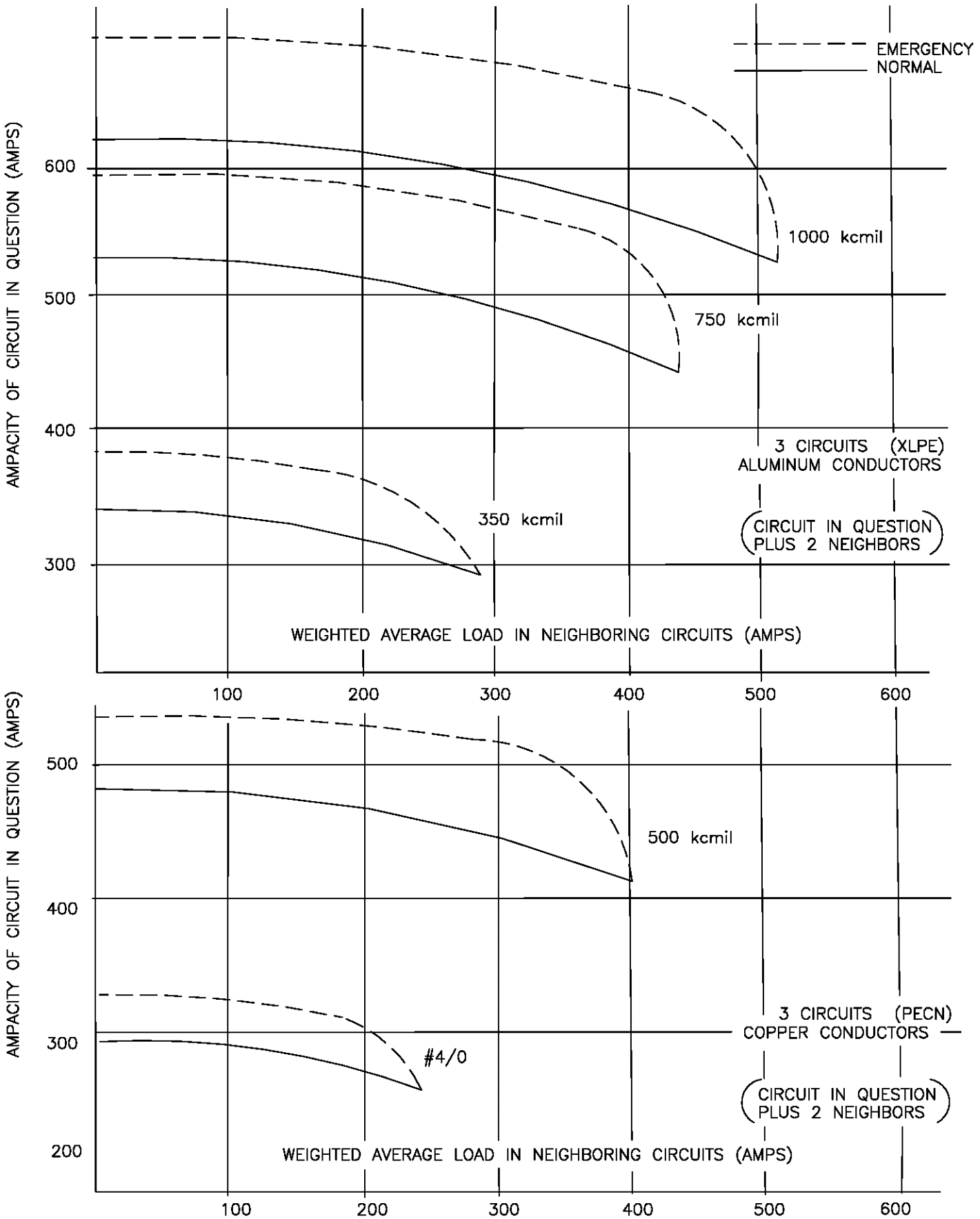
References:

Computer Program EE321, Underground Cable Ampacities and Temperatures Program
Design Standard 6241, Primary Conductor Cost Comparison



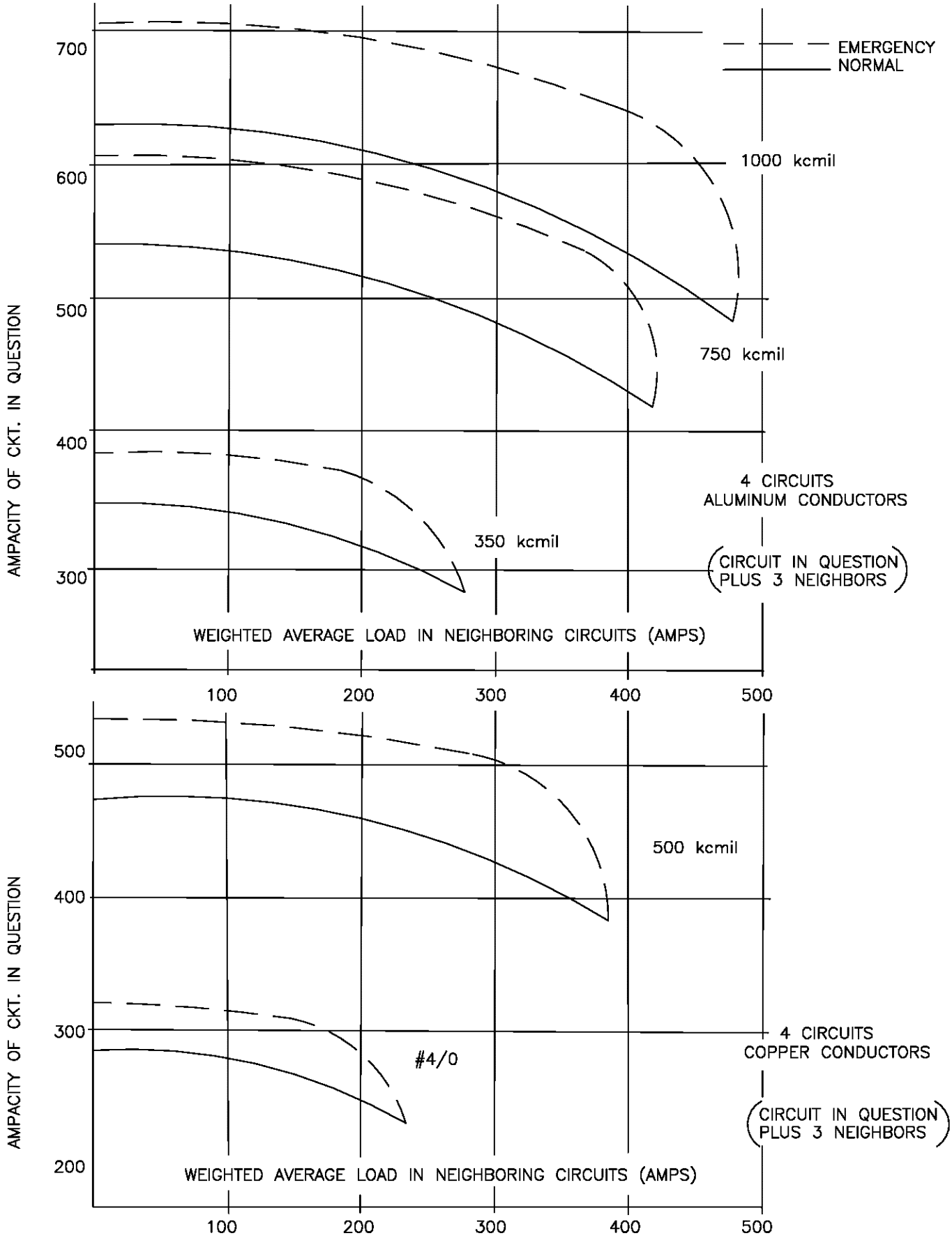
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	SDG&E DISTRIBUTION DESIGN MANUAL	
5521.6	FEEDER CABLE AMPACITIES BASED ON THERMAL LOADING LIMITS	REVISION DATE 1-1-89 APPD CVN/RDJ



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PAGE	SUBJECT
5611	SINGLE-PHASE TRANSFORMER APPLICATION
5612	TRANSFORMER NOISE CRITERIA
5613	THREE-PHASE 120/240V PADMOUNT TRANSFORMER APPLICATION
5614	DEDICATED TRANSFORMERS
5621	INITIAL TRANSFORMER DESIGN LOADING FOR BALANCED LOADS
5625	TRANSFORMER REPLACEMENT GUIDELINE
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SCOPE

This standard establishes application criteria for single–phase transformer stations. It shall be used by District Engineers & Planners designing the distribution system.

CRITERIA

A. Balancing Policy

1. When connecting single–phase 12kV or 6.9kV transformers on a three phase system, they shall be connected such that:

   a. The fuse sizing policies in section 6100 have been met.

   b. The loads are balanced (a) within 150kVA per phase for all installations except fused elbows and (b) 25kVA for fused elbow installations.

   c. 6.9kV (phase–neutral) UG laterals should be limited to 350kVA maximum. For more than 350kVA and less than 700kVA a 2nd. phase wire should be installed and the load split/balanced between the two phases. Greater than 700kVA requires a 3rd. phase with the load again being balanced.

These procedures have been established to reduce current imbalances that can cause improper operation of circuit fuses, substation relays and grounding banks. (See Design Standard 6212, "Effects of Voltage Unbalance on Customer Equipment".)

2. Balancing of 6.9kV Transformers

   a. When connecting 6.9kV transformers on a three–phase circuit they shall be balanced independently of any 12kV single–phase transformer connected on the circuit. This is due to the current and phase differences between the same kVA rated 12kV and 6.9kV transformers.

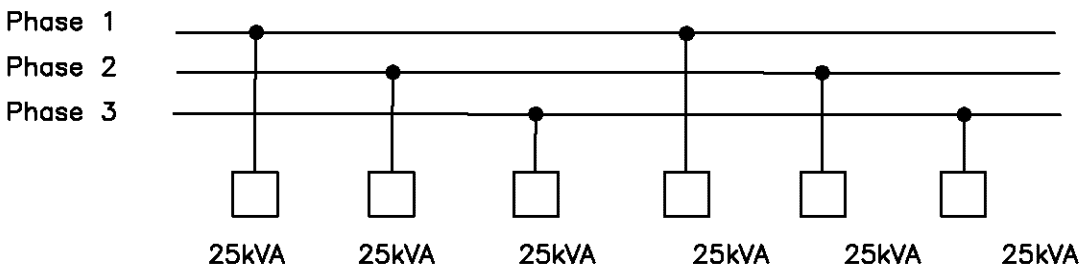
   b. Total single–phase loads connected on the 6.9kV transformer shall be equally divided on each of the three phases or within the criteria stated above, (i.e., total single–phase kVA/3 = load on each phase).

   c. Example

      a. Total single–phase load = 150kVA

      b. Equally divide load on each phase.
      150/3 = 50kVA per phase

      c. Six 25kVA transformers can be used if they are equally divided on the three phases.



3. Balancing of 12kV Transformers

a. When connecting 12kV transformers on a three–phase circuit they shall be balanced independent of any 6.9kV transformers connected on the circuit.

b. Total single–phase loads connected on the 12kV transformers shall be equally divided between each of the three–phases or within the criteria stated in "A" of page 5611–1. (i.e. total single–phase kVA/3 = load between phases 1 and 2, 2 and 3, and 3 and 1).

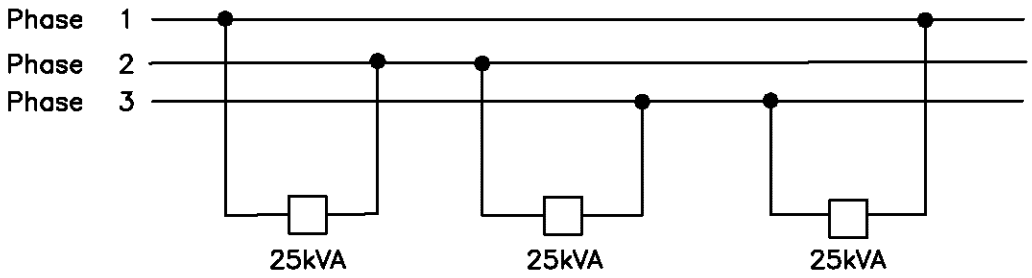
C. Example:

a. Total single–phase load = 75kVA

b. Equally divide load between each phase.

75/3 = 25kVA between phases.

C. Three 25kVA transformers should be used if equally divided between the three phases.



B. Application Of Three–Way Loop, 6.9kV Transformers

1. A single–phase transformer with three primary bushings, prefix NDL & NDS, should be used to serve load in two directions from one transformer. This transformer has provisions for an incoming line, an outgoing line, and a tap line. Refer to Underground Construction Standard 3711. The basic purpose of this transformer is to avoid the cost of installing underground facilities necessary to branch a single phase circuit in two directions.

2. The tap position of the transformer must not serve more than three (3) additional transformers. This is to avoid long outages to a large number of customers, when changing out an NDL & NDS transformer.

3. The balancing policy of this standard must also be met when applying NDL & NDS transformers.

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C. Application of Stainless Steel Transformers

Effective January 1, 2002 all single–phase padmount transformers purchased will be 100% stainless steel. These transformers will be used for all new installations and when replacing corroded single–phase padmount transformers.

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SCOPE

This design standard provides minimum separation distances between padmount transformers and window openings in adjacent buildings to ensure that the sound level at the window opening is within the sound level guidelines established by the City and County of San Diego, or other AHJ for the premise.

DEFINITIONS

- Window Opening – An opening in the building's exterior wall (such as a window that will open or a sliding glass door) that permits transformer noise to radiate inward to an occupied space such as a living room, bedroom, office, etc.
- AHJ - Authority Having Jurisdiction for codes/ordinances at the premise.

CRITERIA

Table 1 provides the minimum separation required between a transformer and a window/door opening. The distance is dependent upon allowable noise, expressed in decibels (dB), established in Table 2.

TABLE 1: TRANSFORMER SEPARATION (V)

ULTIMATE TRANSFORMER			ALLOWABLE NOISE PERMITTED (ONE-HOUR AVERAGE SOUND LEVEL – DECIBELS)				
			40	45	50	55	60
			DISTANCE (FT)				
SIZE	TYPE	PRIMARY CONNECTION					
25–50 kVA	1 Phase	2.4, 6.9 kV	8	5	3	-	-
75–100 kVA	1 Phase	2.4, 6.9 kV	11	7	4	3	-
25–50 kVA	1 Phase	4, 12 kV	8	5	3	-	-
75–100 kVA	1 Phase	4, 12 kV	12	7	4	3	-
167 kVA	1 Phase	12 kV	19	11	5	4	3
250kVA	1 Phase	12 kV	21	12	7	5	3
75 kVA	3 Phase	4, 12 kV	18	11	7	4	3
150 kVA	3 Phase	4, 12 kV	28	16	9	6	4
225-300 kVA	3 Phase	4, 12 kV	30	17	9	6	4
500 kVA	3 Phase	4, 12 kV	34	20	12	7	4
750 kVA	3 Phase	12 kV	43	25	14	8	5
1000 kVA	3 Phase	12 kV	50	29	17	10	6
1500 kVA	3 Phase	12 kV	64	36	21	12	7
2000 kVA	3 Phase	12 kV	77	43	25	14	9
2500 kVA	3 Phase	12 kV	86	49	28	16	9
3000 kVA	3 Phase	12 kV	104	59	34	19	11

TABLE 2: ALLOWABLE NOISE PERMITTED

LAND USE ZONING CLASSIFICATION	NOISE(I)
Single-Family Residential	40 dB
Multi-Family Residential (Up to a Maximum Density of 22 Units/Acre)	45 dB
All Other Residential	50 dB
Commercial	60 dB
Industrial or Agricultural (Any time of the day)	75 dB(II)

(I) Per Article 9.5: Noise Abatement and Control, Division 4: Limits, San Diego Municipal Code (12-2019), based on most restrictive time of day. For AHJ with ordinances that differ from Table 2, their requirements shall apply.

(II) All SDG&E distribution transformers meet the 75dB requirement at normal distances per Design Manual.

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NOTES

I. The following general considerations for noise control shall be observed:

a. Transformers shall be placed away from walls that will reflect noise back toward the window opening under consideration. The ½ cycle wave length of transformer noise is 4.7 feet, this distance or multiples of this distance should be avoided.

b. When a transformer is located within a paved area, leave 6 inches of earth beneath the pad or install a felt expansion joint beneath and around the sides of the pad.

c. When a transformer is located over an underground parking area of a building, it must be placed between bearing walls and not over a bearing wall.

II. It is possible to have different noise requirements on adjacent properties, such as commercial and multi-family. A transformer could be too close to a multiple-family project at a distance that meets the requirements for a commercial building. The applicable minimum transformer distance specified in Table 1 for the adjacent structures zoning classification must be maintained.

III. Transformers located in mobile home parks require additional care to ensure that the transformer will not be too close to a coach or any window openings when a coach is placed on the site at a future date.

IV. If the minimum noise clearances specified in Table 1 cannot be met, a transformer sound enclosure is required in accordance with UG3478, Transformer Sound Enclosure. Alternative mitigations, such as sound walls, may be approved by deviation.

V. Sound studies completed within the last five years showing ambient noise levels higher than the maximum thresholds provided in Table 2 may be used to justify transformer noise levels up to that of the ambient noise level.

VI. For other categories of customers such as hospitals, schools, places of worship etc., refer to the AHJ Code for Noise Abatement and Control.

VII. Applicable formulas:

$$dB_{code} = dB_{NEMA} + 5dB - 20log_{10}\left(\frac{D-1}{0.6\sqrt{W \times H}}\right)$$

$$D = \left\lfloor log_{10}^{-1}\ \left(\frac{dB_{code} - dB_{NEMA} - 5dB}{-20}\right) \times \left(0.6\sqrt{W \times H}\right)\right\rfloor + 1$$

dB_{code} = AHJ noise limit (dB) for zoning category at most restrictive time

dB_{NEMA}= NEMA/IEEE maximum noise limit (dB) for ultimate transformer at premise

$5dB$= aging and load factor added to NEMA limit
D= Distance from transformer to window (ft)
H= Height of transformer tank (ft)
W= Width of transformer tank perpendicular to observer (ft)

REFERENCES

I. San Diego Municipal Code, Article 9.5: Noise Abatement and Control

II. San Diego County Code SEC. 36.404

III. Underground Construction Standard 3478, Transformer Sound Enclosure

IV. NEMA TP 80050-2024

V. IEEE C57.12.20 Annex C Table C.1

VI. Standard Handbook for Electrical Engineers, 16th Ed. 2013, 10-60 10-61

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SCOPE

This design standard provides designers guidance for the selection of three-phase 240/120V padmount transformer installations. This configuration is primary intended for overhead, open or closed delta, to underground conversions with primarily three-phase loads.

CRITERIA

A. Transformers shall be sized in accordance with the DM5621, Initial Transformer Design Loading for Balanced Loads.

B. Designers assigned to perform work on UG conversion projects have the following options when maintaining existing 120/240V secondary, four-wire, three-phase services:

1. If the single-phase load is significant, with modest three-phase and without large three-phase motors, design an open-delta using two pad mount single-phase transformers. Remember, three-phase motors larger than 10 hp cannot be served from an open delta.
2. If the three-phase loads are more significant and include larger three-phase motors, design a closed-delta arrangement using three single-phase 240/120V padmount transformers.
3. If the conditions allow consider the use of the self-contained (replaces HKB and HKR types) 75 or 225kVA HKS padmount to provide 240/120V, three-phase, four-wire service. The loads must be balanced with mostly three-phase load and minimal single-phase load. The HKS "footprint" is smaller, but the height is greater than two or three single-phase padmount transformers, which maybe a consideration for certain installation or customers.

   NOTE: In all cases, use caution when matching transformer kVA to expected loads on these types of existing services.

REFERENCES

I. Electric Distribution Design Manual 5621, Initial Transformer Design Loading for Balanced Loads

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SCOPE

This guideline provides requirements for dedicated transformers for 400 amp and 600 amp single family and multi-family residential panels served from the 2.4kV, 4kV, 6.9 kV, and 12kV voltage systems.

PURPOSE

These guidelines are established so that the potential load served from these panel sizes would not exceed the capacity of the largest single phase transformers stocked by SDG&E at the 2.4kV, 4kV, 6.9kV, and 12kV voltage levels. Allowable loading for a residential transformer is 168 percent, assuming peak load to last 4 hours.

A. A dedicated transformer is required for the following single phase panel sizes:

1. 600 Amp panel served from the 6.9kV
2. 600 Amp panel served from the 2.4kV or 4kv system

Note: A 12kV Single-phase (1-Ø) transformer can serve a maximum of two 600 Amp residential panels.

B. 6.9kV Transformer max load residential

1. 25kVA = 104 Amps x 168% = 175 Amps
2. 50kVA = 208 Amps x 168% = 349 Amps
3. 75kVA = 312 Amps x 168% = 524 Amps
4. 100kVA = 416 Amps x 168% = 699 Amps

C. 12kV Transformer max load residential

1. 25kVA = 104 Amps x 168% = 175 Amps
2. 50kVA = 208 Amps x 168% = 349 Amps
3. 75kVA = 312 Amps x 168% = 524 Amps
4. 100kVA = 416 Amps x 168% = 699 Amps
5. 167kVA = 696 Amps x 168% =1169 Amps

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Table 1:

Number of Costumers	DIVERSITY FACTOR CATEGORIES DM5322-5323		
	Base Load Electric Heating Electric water heating	Air conditioning	
		SF detached	MF, SF attached
1-2	1	1	1
3-4	.75	.85	.70
5-7	.65	.80	.65
8-14	.55	.75	.65
15+	.50	.70	.60

Multi Family Criteria:

Multifamily Scenarios for dedicated transformers

A. 6.9kV & 2.4kV System

1. 4-400 Amp Panels: (4 x 400) = 1600 x 80% panel demand x .55 diversity = 704 Amps **(One transformer cannot serve this scenario)**. At .65 diversity load is 832 Amps **(One transformer cannot serve this scenario)**

2. 3-400 Amp Panels: (3 x 400) = 1200 x 80% panel demand x .55 diversity = 528 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 624 Amps **(One transformer can serve this scenario)**

3. 1-600 Amp & 1-400 Amp Panels: (600+400) = 1000 x 80% panel demand x .55 diversity = 440 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 520 Amps **(One transformer can serve this scenario)**

4. 1-600 Amp & 2-400 Amp Panels: (600+800) = 1400 x 80% panel demand x .55 diversity = 616 Amps **(One transformer can serve this scenario).** At .65 diversity load is 728 Amps **(One transformer cannot serve this scenario)**

5. 2-600 Amp Panels: (2 x 600) = 1200 x 80% panel demand x .55 diversity = 528 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 624 Amps **(one transformer can serve this scenario)**

B. 12kV & 4kV System

1. 6-400 Amp Panels: (6 x 400) = 2400 x 80% panel demand x.55 diversity = 1056 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 1248 Amps **(One transformer cannot serve this scenario)**

2. 5-400 Amp Panels: (5 x 400) = 2000 x 80% panel demand x .55 diversity = 880 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 1040 Amps **(One transformer can serve this scenario)**

3. 1-600 Amp & 2-400 Amp: (600+800) = 1200 x 80% panel demand x .55 diversity = 616 Amps **(One transformer can serve this scenario)**. At .65 diversity load is 728 Amps **(One transformer can serve this scenario)**

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SCOPE

This design standard provides the allowable initial transformer design loading for balanced three-phase and single-phase estimated demands served by open-delta, closed-delta and three-phase padmounted transformer stations. This practice only applies to those transformer stations in which the single-phase load is equally divided among the three incoming phases.

PURPOSE

This standard was developed to provide improved initial transformer utilization considering allowable voltage drop and economic loading levels. Higher transformer loading may be achieved with Design Standards approval when the secondary/service voltage drop is less than 2.0 percent for single-phase and 1.0 percent for three-phase transformers.

DEFINITIONS

Initial Transformer Design Loading Range – The transformer loading criteria for the initial installation that allows for future load growth.

Estimated Demand - the chosen demand estimate based on the Demand Estimating Guidelines provided in Design Manual Section 5300.

Equivalent Demand - the calculated demand required to allow the proper transformer selection based on individual transformer winding load.

CRITERIA

TABLE 1:

THREE-PHASE PADMOUNTED TRANSFORMERS				
TRANSFORMER SIZE (kVA)	120/208V		277/480V	
	kVA	kW	kVA	kW
75	0-88	0-74	0-88	0-74
150	89-176	75-135	89-176	75-135
225	177-264	136-224	177-264	136-224
300	265-352	225-299	265-352	225-299
500	353-588	300-499	353-588	300-499
750	589-825	500-701	589-825	500-701
1000	826-1100	702-935	826-1100	702-935
1500	1101-1650	936-1402	1101-1650	936-1402
2000			1651-2200	1735-1870
2500			2201-2750	1871-2337
3000			2751-3300	2338-2805

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TABLE 2:

SINGLE PHASE PADMOUNTED TRANSFORMERS		
TRANSFORMER SIZE (kVA)	**kVA**	**kW**
25	0-33	0-29
50	34-67	30-60
75	68-100	61-90
100	101-134	91-120
167	135-224	121-201

TABLE 3:

SINGLE-PHASE POLEMOUNTED TRANSFORMERS				
TRANSFORMER SIZE (kVA)	**RESIDENTIAL**		**COMMERCIAL**	
	kVA	**kW**	**kVA**	**kW**
15	0-20	0-18	0-17	0-14
25	21-33	19-29	18-29	15-24
50	34-67	30-60	30-58	25-49
75	68-100	61-90	59-88	50-74
100	101-134	91-120	89-117	75-99
167	135-224	121-201	118-196	100-166

Note: Initial transformer loading assumes Power Factor = 0.90 for single phase residential, 0.85 for commercial.

1. Single-Phase Transformer Stations

   Use the diversified demand estimate determined from Design Standard 5322, "Residential Demand Estimating" to select the proper size transformer from table 2 or 3.

2. Three-Phase Transformer Stations

   An attempt should be made to balance the single-phase load equally within the three-phase transformer station windings. This may be done by placing 1 /3 of the total single-phase load between each pair of the three incoming phases (see Design Standard 5611, "Single-Phase Transformer Application").

   a. 1. 120/208V three-phase power is obtained from a three-phase padmounted transformer station. Use the total diversified three-phase and single-phase demand estimate determined from Design Standard 5311, "Three-Phase Demand Estimating Criteria" to select the proper size transformer from table 1.

   b. 120/240V three-phase power is obtained from an open-delta or closed delta overhead transformer station

      i. Closed Delta (large three phase loads with small single phase loads are served most efficiently by the closed delta configuration)

      If the single-phase load is equally divided among the three transformers, use 1 /3 of the total three-phase and 1 /3 of the total single-phase demand estimate to select three equally sized single-phase transformers from table 2 or 3. Otherwise, select unequal transformers in accordance with Table 1 on OH Construction Standards page 1105.1.

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ii. Open Delta (small three phase loads with large single phase loads are served most efficiently by the open delta configuration)

If the single-phase load is balanced across the three-phase lines, use 58 percent of the total three-phase and single-phase demand estimate from Design Standard 5311 to select two equally sized single-phase transformers from table 2 or 3.

If all of the single-phase load is connected across only two I lines, the two single-phase transformers may not be equally sized. To determine the proper size single-phase transformer:

1) Smaller Single-Phase Transformer - use 58 percent of the three-phase demand estimate from Design Standard 5311 to select the proper size transformer from table 2 or 3.

2) Larger Single-Phase Transformer - use 58 percent of the three-phase and all of the single-phase demand estimate from Design Standard 5311 to select the proper size transformer from table 2 or 3.

c. 120/240V three-phase power obtained from the type HKS padmounted transformer is similar to the overhead closed delta station of subparagraph B.2.a. For unbalanced single-phase load simply add twice the single-phase load to the three-phase load to determine the three-phase kVA requirements.

d. 120/208 4W, 3Ø, an overhead station delta-wye bank, the procedure is to take 1/3 of the three phase load plus 1/3 of the total single phase load to equally size each transformer.

EXAMPLES

1. 1. Select the proper transformers to serve an estimated demand of 70 kW (60 kW non-motor load and 10 kW motor load) three-phase load and 10 kW of balanced (between the two PS legs) single phase load.
The load may be served from either an open-delta or closed-delta polemounted three-phase transformer station or a three-phase padmounted transformer station.

a. Open-delta polemount:
   i. Determine the equivalent demand
   70kW, 3Ø x 0.58 = 40.6, 3Ø
   10kW, 1Ø x 1 = 10kW, 1Ø
   ii. Determine total equivalent demand
   40.6 + 10 = 50.6kW
   iii. Select the proper transformers
   2-50kVA transformers required

b. Colsed-delta polemount:
   i. Determine the equivalent demand
   70kW, 3Ø x 1/3 = 23.3 kW, 3Ø
   10kW, 1Ø x 1/3 = 3.3 kW, 1Ø
   ii. Determine total equivalent demand
   23.3 + 3.3 = 26.6kW
   iii. Select the proper transformers
   3-25kVA transformers required

c. Three-phase padmount:
   i. Determine the equivalent demand
   70kW, 3Ø x 1 = 70kW, 3Ø
   10kW, 1Ø x 1 = 10kW, 1Ø
   ii. Determine total equivalent demand
   70 + 10 = 80kW

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i. Select the proper transformer
1-75kVA transformer required

2. Select the proper transformers to serve a three-phase estimated demand of 10kW with an additional single-phase demand of 70kW connect across one transformer.

The load should be served from either a polemounted or padmounted open-delta transformer station to prevent oversizing the transformers.

a. Open-delta polemount:
   i. Determine the equivalent demand
   10kW, 3Ø x 0.58 = 5.8kW, 3Ø
   70kW, 1Ø x 1 = 70kW, 1Ø
   ii. Determine the total equivalent demand
   5.8 + 70 = 75.8kW on the larger transformer
   5.8 + 0 = 5.8kW on the smaller transformer
   iii. Select the proper transformers
   1-75kVA & 1-10kVA transformer required

b. 120/240 padmount:
   i. 10 + 2 (70) = 150
   ii. Selected 150kVA

3. Select the proper transformer to serve three single-phase estimated demands of 10kW, 15kW, and 20kW, respectively
   a. Single-phase polemount:
      i. Determine the total equivalent demand
      10 + 15 + 20 = 45kW
      ii. Determine the proper diversity factor from Table 3, Design Manual Standard 5322, "Residential Demand Estimating"
      45kW x 0.75 = 33.8kW
      iii. Select the proper transformer
      1-50kVA transformer required
   b. Single-phase polemount
      i. Using the equivalent diversified demand from above
      1-50kVA transformer required

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References:

1. Design manual Standard 5311, Three Phase Commercial Demand Estimating Criteria
2. Design manual Standard 5322, Residential Demand Estimating
3. Overhead Construction Standards 1105-1107, Transformer Loading Guide for 3Ø Stations with 1Ø Transformers

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C							F						
B	EDITORIAL CHANGES	EPC	FRC	VMV	CZH	08/20/2021	E						
A	ORIGINAL				SRM	01/01/1998	D						

SCOPE:

This design standard establishes the allowable transformer load limits before the replacement of three–phase and single–phase transformer station (padmounted and pole mounted). The change out loading limits were developed based on the thermal limits of transformers.

PURPOSE

This standard is intended to prevent unnecessary expenditure and promote efficiency when transformer replacement is being considered. Load limits in the table below are only a guide and do not take into consideration voltage problems associated with these loads.

Separate load limits were developed for residental and commercial customers because the duration of peak loads is usually different. Residential peak loads are assumed to last 4 hours. Commercial peak loads are assumed to last 8 hours.

DEFINITIONS

Transformer change out or replacement loading limit – the load at which the decision to replace a transformer is made.

CRITERIA

TABLE–1 THREE–PHASE PADMOUNTED TRANSFORMERS

Transformer Size (kVA)	Residential 168%		Commercial 147%	
	kVA	kW	kVA	kW
45	76	68	66	56
75	126	113	110	94
150	252	227	221	187
225	378	340	331	281
300	504	454	441	375
500	–	–	735	625
750	–	–	1103	937
1000	–	–	1470	1250

TABLE–2 SINGLE–PHASE PADMOUNTED TRANSFORMERS

Transformer Size (kVA)	Residential 168%		Commercial 147%	
	kVA	kW	kVA	kW
15	25	23	22	19
25	42	38	37	31
50	84	76	74	62
75	126	113	110	94
100	168	151	147	125
167	281	253	245	209

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TABLE–3 SINGLE–PHASE POLEMOUNTED TRANSFORMERS

Transformer Size (kVA)	Residential 168%		Commercial 147%	
	kVA	kW	kVA	kW
10	17	15	15	12
15	25	23	22	19
25	42	38	37	31
50	84	76	74	62
75	126	113	110	94
100	168	151	147	125

NOTES:

If the duration of peak loads exceed the hours stated above, consult Distribution Planning.

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SCOPE

This design standard was developed to provide the Customer Project Planner with a guide to determine the appropriate transformer and service lateral conductors to serve a fire pump.

DEFINITIONS

- Fire Pump – A pump that provides water to a building that would be used in the event of a fire.
- Jockey Pump – A small pump connected to a fire sprinkler system to maintain pressure in the sprinkler pipes.
- Auxiliary Loads – Pump controllers and other equipment associated with the fire pump that are not motors.

CRITERIA

National Electric Code (NEC) Article 430 and 695 indicates that provisions for motor and branch circuit running overload protection are not to be interpreted as requiring overload protection where it might introduce additional or increased hazards as in the case of fire pumps. Fire pump motors are required to have much larger overcurrent protection than other motors. The NEC recognizes that fire pumps must be allowed to operate to failure rather than removing them from the line in fire conditions. The overcurrent protection is actually short circuit and ground fault protection since the motor is to operate to failure.

SDG&E intends to size Fire Pump transformer(s) and service lateral conductors to hold the Lock Rotor Current(s) indefinitely.

EXAMPLE

A. It is necessary to serve a 125 horsepower (HP) fire pump motor with a 480 Volt, 3-phase with motor nameplate code letter "G". In addition, there is a 2 HP, 480 Volt, 3-phase Jockey Pump with code letter H. Table 1 provides the Locked Rotor Currents (LRC) per motor horsepower for each letter code. There is a total of 2kVA of auxiliary loads at full current.

a. Step 1 – Find the Locked Rotor Current for each motor:

$$LRC\ (125\ HP) = \frac{6.29\ kVA * 125\ HP}{HP} = 786.3\ kVA$$

$$LRC\ (2\ HP) = \frac{7.09\ kVA * 2\ HP}{HP} = 14.18\ kVA$$

b. Step 2 – Add the total motor kVA:

$$kVA = 786.3\ kVA + 14.18\ kVA = 800.5\ kVA$$

c. Step 3 – Add the motor loads and Auxiliary loads.

$$kVA = 800.5\ kVA + 2\ kVA = 802.5\ kVA$$

d. Step 4 – In Table 2: Transformer Max Loading for Fire Pumps Only, identify which Transformer size suites this example. For a 802.5 kVA load, a 500 kVA transformer is suitable.

e. Step 5 – See Underground Standards 3700 and select the transformer type needed. For this example, a 500 KVA Type HNS, S761328 is the correct transformer.

B. The service lateral conductor size and the number of runs should then be selected to handle the capacity of the 500 kVA transformer. As a rule of thumb, every 400A of load requires one conduit. See Service Standards 309.1 or note 2 in Service Standards 709.3 for additional information.

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A	Original Issue	-	-	JCE	VCR	03/01/2002	D						

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C. Most of the fire pump installations are in high-rise buildings fed from a large service and transformer. The transformer and service are normally already sized adequately based on SDG&E's estimated demand load, voltage drop, and flicker calculation to serve a fire pump. However, there may be situations where this is not the case, and it is important to make sure the transformer and service lateral conductors are sized to serve the fire pump.

NOTE: When sizing a transformer with a fire pump, the larger size transformer from the analyses done from DM5621 and DM5626 shall be used. When the smaller size transformer is preferred an approved Deviation Request is required.

REFERENCES

I. National Electrical Code, 2023 Article 695, Fire Pumps

II. National Electrical Code, 2023 Article 430, Motors, Motor Circuits, and Controllers

III. Electric Distribution Design Manual 5621, Initial Transformer Design Loading for Balanced Loads

IV. Underground Construction Standard 3700, Transformers

V. Underground Construction Standard 4314, Transformer Fusing Tables

VI. Service Standards Guide 309.1, Underground Electric Service Lateral Conduit Requirements

VII. Service Standards 709.3, Cable Termination Bus Stubs in Underground Pull Cans or Pull Section

APPENDIX

Table 1: Locked Rotor Currents

Reference NEC 2023 Table 430.7 (B)

Locked-Rotor Indicating Code Letters AMPS			
Code Letter	**kVA per HP**	**Code Letter**	**kVA per HP**
A	0 - 3.14	**L**	9.0 – 9.99
B	3.15 - 3.54	**M**	10.0 – 11.19
C	3.55 – 3.99	**N**	11.2 – 12.49
D	4.0 – 4.49	**P**	12.5 – 13.99
E	4.5 – 4.99	**R**	14.0 – 15.99
F	5.0 – 5.59	**S**	16.0 – 17.99
G	5.6 - 6.29	**T**	18.0 – 19.99
H	6.3 – 7.09	**U**	20.0 – 22.39
J	7.1 – 7.99	**V**	22.4 and up
K	8.0 - 8.99		

Table 2: Transformer Max Loading for Fire Pumps Only

Maximum Transformer Loading		
Transformer size KVA	**Internal Fused**	**Max. KVA**
75	6	125
225	15	331
300	25	519
500	40	831
750	65	1351
1000	65	1470
1500	100	2205
2000	125	2940
2500	125	3675

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SCOPE

This standard provides application guidelines for installing regulators.

DEFINITIONS

Single Phase Regulator – A transformer which provides a voltage output from minus to plus ten percent of its input voltage in thirty–two, 5/8 percent steps.

Reversible Feed Regulator – A regulator which will, under reverse power flow conditions, short out the compensation and regulate the non–substation output voltage. This regulator is to be used only for locations where reverse power flow can be experienced due to co–generators.

Auto Booster Voltage Regulator – A regulator with limited voltage regulation above or below the input voltage, but not both. Due to a number of limitations, these units are no longer purchased.

APPLICATION GUIDELINES

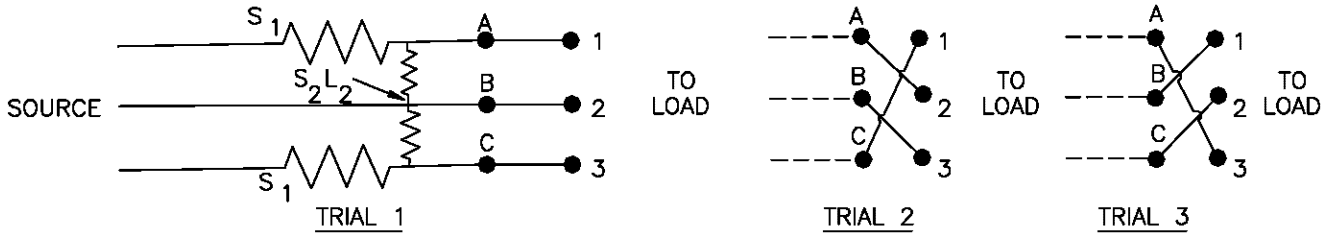
1. On three–phase, three–wire circuits, regulators should be connected either open–delta using two regulators or closed delta using three regulators. The addition of the third regulator and closing the delta does not permit the regulator bank to carry more load, but it does increase the regulation range of the bank by approximately 50 percent. That is, when installing three, ±10 percent single–phase regulators in closed delta, the regulation range of the three–phase bank is approximately ±15 percent.

2. On three–phase, three–wire circuits, the use of three single–phase regulators connected in wye is not recommended. The neutral or common point of the wye connection would be floating, and unbalanced load conditions or different regulator control response characteristics could cause this point to shift. With individual regulator controls, unstable operation could result.

3. On three–phase, four–wire circuits, regulators should be connected wye with the neutral tied to the system neutral. Do not install regulators open–delta since no regulation is provided for load connected on the third phase.

4. When either two or three single–phase regulators are connected delta, the line current through the series winding will be shifted 30 degrees with respect to the voltage across the exciting winding. As a result, the voltage from the line drop compensator will not subtract in proper phase from the control winding voltage being applied to the contact–making voltmeter, unless provision is made to correct for this phase shift. On later model regulators having a Phase–Shift Selector built into them, or on regulators provided with a Phase Shift Transformer, care must be taken to make connections or settings in accordance with the manufacturers instruction book. On regulators without phase shift correction, an increase in line–drop compensator setting will partly offset the effect of phase difference under usual load conditions.

5. When two single–phase regulators are connected open delta, the voltage on the phase with no regulator may be higher or lower than the voltage on either of the other phases. The amount of voltage unbalance will depend upon the unbalance in the load, the power factor of the load, the phase rotation and the connection used. If the connection initially used does not result in satisfactory voltage balance at the load center, a different connection should be tried as shown below for regulator installations which do not feed tie points with other circuits. This may be accomplished by means of a transposition in the line on the load side of the installation.



6. The reversible feed regulator is to be used only on circuits where a reverse power flow can be expected at the regulator due to a co–generator on the circuit. These regulators, under reverse power conditions, will eliminate all compensation and will continue to regulate voltage on the non–substation side of the regulator. Experience thus far has shown that these co–generators will have less control over the voltage at the regulator installation than our system will. Such installations should initially be monitored to make sure that proper voltage regulation is being obtained. These regulators are not to be used for situations in which reverse power flow can be expected from a different substation due to circuit reconfiguration.

7. Make sure regulator is in the neutral position and on "Manual" control before operating bypass–disconnect switches.

8. All Distribution Feeder Voltage Regulators purchased in 1958 or later, and regulators of some manufacturers purchased earlier, have provision for obtaining added load capacity. This feature is designated by various manufacturers as "Vari–Amp", "Load Bonus", or "Add–Amp". To accomplish this, it is necessary to restrict the voltage regulating range. The table below shows the current rating in amperes that may be obtained with each of the five regulating ranges. Consult manufacturers' instruction books for procedure to adjust regulating range.

   If full ±10% regulating range is not required for a given application, cost savings can be achieved by specifying a regulator of reduced Kva capacity.

REGULATOR BASE AMPERES	BOOST OR BUCK RANGE				
	10%	±8–3/4%	±7–1/2%	±6–1/4%	±5%
25	25	27.5	30	34	40
50	50	55	60	67.50	80
100	100	110	120	135	160
200	200	220	240	270	320

9. APPLICATION OF AUTO–BOOSTER VOLTAGE REGULATORS

Auto–Booster Voltage Regulators (also called Auto–Boosters, or 4–Step Regulators) are lower in cost than the 32–step Distribution Feeder Voltage Regulators. However, they have certain characteristics which limit their use. These characteristics are:

a) They change voltage in large steps (4 steps of 1–1/2% each for the 6% range Auto–Boosters).
b) They have a wide band width (2.8 volts for 6% Auto–Boosters).
c) They do not have line drop compensation.
d) They do not have adjustable time delay nor position indicators.
e) They may be connected either boost or buck, but not both. When installed to boost voltage, they cannot lower it unless it exceeds the top of the control band width.

Because of their limitations, auto–boosters are no longer purchased for new installations.

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PADS & SUBSTRUCTURES

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B	Editorial Changes	EDM	ADW	JES	KRG	04/22/2022	E						
A	Revision	-	-	JCE	VCR	03/01/2002	D	Editorial	YZZ	JES	FRC	JJP	10/31/2025

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SCOPE

This design standard is for conduit and substructure selection, based on the underground feeder circuit and underground local distribution cable run requirements.

PURPOSE

This standard was developed to maintain substructure unobstructed space in accordance with Underground Construction Standard section 3600.

DEFINITIONS

Underground Feeder Circuit – the term applied to unfused three–phase 600 amp primary underground cable runs where 350, 750 or 1000 kcmil cable enters and leaves a substructure.

Underground Local Distribution Cable Run – the term applied to fused or unfused three–phase 200 amp primary underground cable runs where #2 or 2/0 cable enters or leaves a substructure.

GUIDELINE

Table 1 – Substructure and conduit selection based on ultimate 3–phase underground feeder circuit and underground local distribution cable run requirements.

FEEDER CIRCUIT REQUIREMENTS												
	10	10EB5"	3326–20'	3326–20'	3326–20' 3523	3326–20' 3523	3326–20' 3523	3326–20' 3316	3326–20' 3316	NOT APPLICABLE	NOT APPLICABLE	NOT APPLICABLE
	9	9EB5"	3326–20'	3326–20'	3326–20' 3523	3326–20' 3523	3326–20' 3523	3326–20' 3316	3326–20' 3316			
	8	8EB5"	3326–20'	3326–20'	3326–20' 3523	3326–20' 3523	3326–20' 3523	3326–20' 3316	3326–20' 3316			
	7	7EB5"	3326–20'	3326–20'	3326–20' 3523	3326–20' 3523	3326–20' 3523	3326–20' 3316	3326–20' 3316			
	6	6EB5"	3325–14'	3325–14'	3325–14' 3523	3325–14' 3523	3325–14' 3523	3325–14' 3316	3325–14' 3316			
	5	5EB5"	3325–14'	3325–14'	3325–14' 3523	3325–14' 3523	3325–14' 3523	3325–14' 3316	3325–14' 3316			
	4	4EB5"	3316 ⑤	3316	3316 3523	3316 3523	3316 3523	3316 3316	3316 3316			
	3	3EB5"	3316	3316	3316 3523	3316 3523	3316 3523	3316 3316	3316 3316			
	2	2EB5"	3315 ⑤	3316	3316	3316	3316	3316 3315	3315 3316	3316 3316	3316 3316	3316 3316
	1	1EB5"	3315	3315	3315	3315	3315	3316	3315 3316	3315 3316	3315 3316	3315 3316
	0	---	SUBSTR.	3523	3523	3523	3523	3316	3316	3316 3523	3316 3523	3316 3523
		CONDUIT	---	1DB4"	2DB4"	3DB4"	4DB4"	5DB4"	6DB4"	7DB4"	8DB4"	9DB4"
	CIRCUIT OR CABLE RUN QUANTITY (3Ø)		0	1 Ⓐ	2	3	4	5	6	7	8	9
				LOCAL DISTRIBUTION CABLE RUN REQUIREMENTS								

☒ Indicates Latest Revision	☐ Completely Revised	☐ New Page	
REVISION DATE 3–1–02 APPD JCE	SDG&E DISTRIBUTION DESIGN MANUAL CONDUIT & SUBSTRUCTURE SELECTION CRITERIA	5711.1	

NOTES:

A. Table 1 assumes that all cable is terminated with connectors within the substructure. If a substructure contains terminated and straight–through cables, the substructure selection should be made based on terminated cables only and then verified with applicable Construction Standards to determine if the additional straight–through can be accommodated.

B. A single local distribution cable run requirement does not allow for future local distribution cable runs because it must originate from 200A deadbreak elbows connected to 600A deadbreak tees.

C. Substructure selection is made at the intersection of Feeder Circuit and Local Distribution Cable Run Requirements. When two substructures are shown, both are required.

D. To properly apply the guideline, all fuse cabinets require only one cable run to supply the load (Note: the source is obtained from 200A load–break elbows connected to 600A deadbreak tees).

E. The substructure requirements for 2 through 8 local distribution cable runs permit 3–phase loadbreak termination of each cable run. When single–phase equipment or combinations of loadbreak and deadbreak equipment are desired, consult Underground Construction Standards section 3600.

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The following assumptions apply to this guideline:

1. Local distribution cables shall not occupy a 5" conduit unless approved by Distribution Planning.

2. Ultimate feeder circuit requirements are specified by District Engineering and are generally supported by the long term feeder arrangement plan for the area.

3. The 3315 and 3316 substructures intended to house 1 local distribu–tion cable run and an ultimate of 2 and 4 feeder circuits respectively shall have a note indicating "FEEDER ONLY" on job print in accordance with the Mapping & Records Section – DFIS Manual page SI–4.

4. When two substructures are required at the same trench location to serve the primary circuit configuration, a minimum separation of 25 feet between exterior walls shall be maintained to allow for feeder conduit sweeps occurring between substructures.

5. When local distribution is not required and an odd number of feeder conduits exist, an additional EB5" is NOT to be installed in vacant conduit spacer position provided substructure selection is not affected.

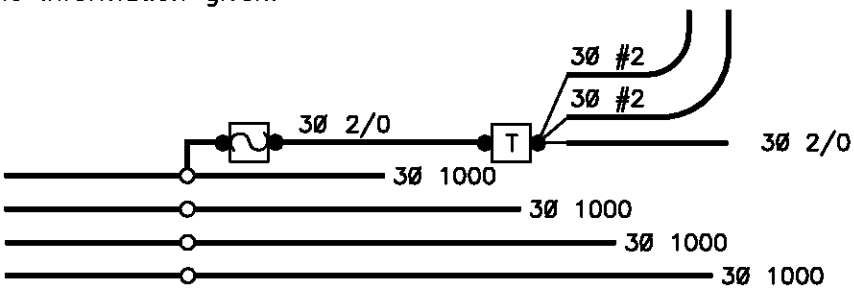
Example:

Determine the conduit and substructure requirement assuming that the feeder and local distribution circuits occupy the same trench.

Given:

- Distribution Planning has indicated that 2–1000 Kcmil AL feeder circuits are initially required.
- Long–term feeder arrangements require 4–1000 Kcmil AL feeder circuits.
- A fused local distribution circuit (1–3/C #2/0 AL) is required to serve 2–150 HZB transformers from 3–1/C #2 AL.

1. Sketch the electrical single line for the ultimate configuration from the information given.



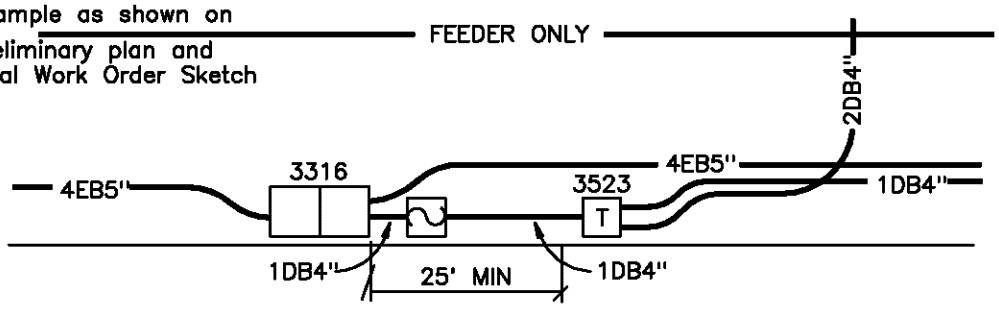
2. Determine the ultimate number of feeder circuits required in the substructure(s):
   – 4

3. Determine the number of local distribution cable runs required in the substructure(s):
   – 4 (1–fuse cabinet, 2–transformers, 1–outgoing circuit)
   Note: fuse cabinets require one cable run (page 5711.2, note D)

4. Select the substructure(s) required from the guideline:
   – 3316 – for feeder circuit requirements
   – 3523 – for local distribution cable run requirements

5. Assign the conduit requirements to the substructure(s) from the guideline. The following conduit and substructure sketch results:

Figure 1 – Example as shown on Preliminary plan and Final Work Order Sketch



References:

1. Construction Standards Section 3300, Substructures and Conduits
2. Construction Standards Section 3600, Subsurface Sectionalizing Equipment

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SCOPE

This design standard provides criteria for siting and application of secondary pre-engineered substructures such as prefabricated handholes and box pedestals in residential designs. These criteria have been developed to promote cost-efficient design, operation and maintenance of the SDG&E underground electric distribution secondary system.

CRITERIA

A. Location of Secondary Handholes and box pedestals (3309, 3310, 3312, & 3313).

Secondary handholes and box pedestals are used to provide access to secondary and service cables in addition to providing a place for cable pulling and connections made with secondary cable connectors and compression lugs. The location of secondary handholes and box pedestals is determined by the following factors:

1. Secondary handholes are to be placed to avoid excessive service runs so as not to exceed pulling tension limitations (see Distribution Design Manual 5233, Cable Pulling Tensions, Primary and Secondary). Setting depth of substructures must be limited to depths shown in Underground Construction Standards to avoid unnecessary excavation and cable de-rating.
2. The normal location for handholes in residential subdivisions is behind the sidewalk, adjacent to the common lot line. In non-subdivision areas, the handhole must be installed in an area where motor vehicles cannot drive or park on it.
3. Most secondary handholes are to serve a minimum of two lots.
4. Install 3313 handhole with traffic cover if handhole cannot be located away from traffic or in a non-traffic area.
5. Changes in grade may require the use of box pedestals or retaining walls to ensure equipment is accessible and out of traffic. Substructures are to be located near the property line where cars will not be driven or parked.
6. Box pedestals may be required in green-belts, areas of extreme wet environment or areas of high vegetation or other similar areas. If possible, equipment should not be placed in "bio-swales" or drainage basins.

B. Application of Secondary Handholes and Box Pedestals

1. Secondary handholes and/or box pedestals are required when:
   a. The equipment type and number of secondary and service runs apply to UG3302.
   b. The equipment type and number of secondary and service runs apply to UG3605.
2. Secondary handholes and/or box pedestals are not required when:
   a. Conduit services do not exceed the pulling tension requirement (see UG4005, Cable Pulling Tension, Primary and Secondary).
   b. The amount of trench required for secondary cable with handholes versus individual service laterals is the same.
   c. The cost of an additional service cable does not exceed the cost of the handhole (this applies only when more than two services are involved).

REFERENCES

I. Underground Construction Standard 3300, Substructures

II. Underground Construction Standard 3400, Pads, Retaining Walls & Clearances

III. Underground Construction Standard 3605 Substructure Use and Limitations Reference Sheets

IV. Underground Construction Standard 3942, Underground Electric Service Lateral – Customer Installed Conduit, Residential or Commercial

V. Underground Construction Standard 4005, Cable Pulling Tension, Primary and Secondary

VI. Underground Construction Standard 4175, 0–600 Volt Connectors for #8 Through 500 Kcmil Aluminum or Copper Conductors & Handhole Installation

VII. Electric Distribution Design Manual 5233, Cable Pulling Tensions, Primary and Secondary

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

SECONDARY HANDHOLE APPLICATION REQUIREMENTS

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SCOPE

This design standard provides supplementary criteria for selection of the occupied conduit position within substructures. Primary considerations are provided in Underground Standards sections 3646 and 3649. Apply the criteria presented in this standard when the UGS does not cover your specific application.

PURPOSE

This standard was developed to provide a safe working environment for construction personnel in accordance with Underground Standards 3646 & 3649.

DEFINITIONS

Circuit Position – the cable racking position (either horizontal or vertical) for individual conductors of a three–phase circuit.

Occupied Knockout – the conduit position within a particular conduit array that is occupied by a particular feeder circuit or local distribution cable run.

Conduit Array – the grouping of conduit positions at the entrance to a substructure such as columns A–B or C–D (as shown in the examples).

Transition Area – the radial area adjacent to substructures where conduits transition from stacked configuration (main trench) to a pattern compatible with substructure knockouts.

CRITERIA

The occupied knockout depends on the equipment installed in the substructure.

A. Switches : see UG standard 3649 for technical illustrations.
   1. Cables must enter the manhole in the conduit array nearest the wall that is opposite of the switch.
   2. Connectors and splices must be placed on the wall opposite the switch.
   3. Switches must be placed nearest the wall that is opposite of the manhole opening.

B. Connectors, splices : see UG standard 3646 & 3649 for technical illustrations.
   1. Cables may enter manholes in the conduit array nearest either wall; the wall with connectors or splices is preferred.
   2. Feeder cables must be racked or terminated on the same wall with the connectors or splices and therefore must enter and leave the handhole that is nearest the wall with terminating equipment.
   3. Connectors or splices may be placed within a manhole without regard to the manhole opening when a switch or future switch is not a consideration..
   4. Cable pulled straight through manholes or handholes must enter and leave the substructure on opposite end walls in the knockout position directly across from each other.

C. The following limitations apply to all equipment:
   1. Local distribution cable may be racked either horizontally or vertically, provided that horizontal racking does not cause the cable to interfere with the unobstructed space or future cable pulling & training.
   2. Feeder cable may only be racked horizontally in manholes, vertically in handholes.
   3. The preferred entrance for feeder and local distribution cables is on the same wall, but they may enter a manhole in the conduit array nearest the wall that is opposite of connectors or splices.
   4. Local distribution cable may enter a handhole in the conduit array nearest the wall that is opposite of connectors or splices, but feeder cables must enter and exit a handhole on the same wall as the connectors or splices.

5. When two cable runs will occupy adjacent conduits they may be positioned either horizontally or vertically according to the following rules (refer to examples for label reference):
   - the bottom row of conduits (number 1) must be filled by cable prior to using the next row (number 2).
   - the lowest available horizontal row must be occupied prior to going up to the next row.
   - the first cable installed must occupy the outside conduit position (such as A or D).

6. Local distribution cables are to occupy conduits closer to the surface. Feeder cables shall be installed in the lower conduits.

7. Conduit branching from the main trench should occupy a position in the duct bank on the same side as branching is intended.

8. Conduit routed to facilities in close proximity to substructures should be designed to avoid crossing conflicts with other conduits in the transition area.

   Conduits cannot cross through the transition area if they are impeded by other conduits occupying the same elevation. Use discretion to select a preferred conduit position that will avoid crossing conflicts.

   If unable to avoid crossing conflicts select an alternate conduit position on adjacent corner of substructure.
   See figure 1 below.

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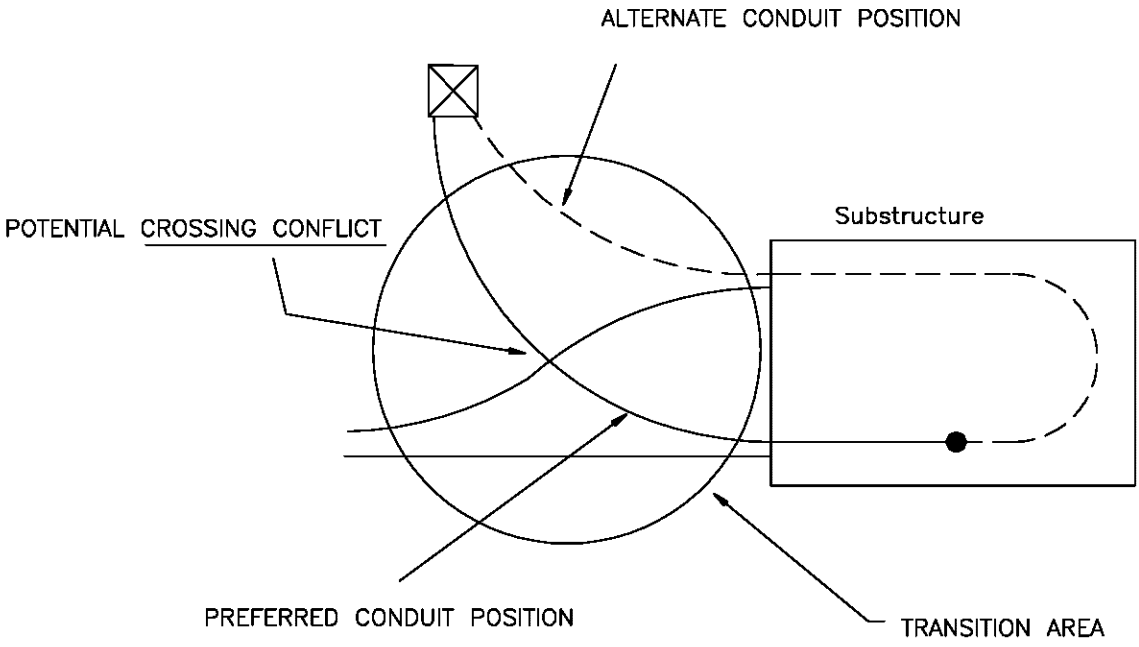


FIGURE 1

EXAMPLES:

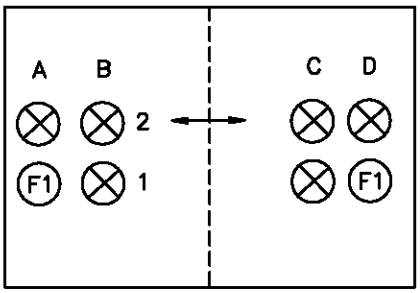
The following examples show various possible cable knockout positions for manholes and handholes.

- Most of the examples have a vertical line with an arrow (⟷) to show the knockout positioning on either side of the substructure. This does not mean that cable can occupy both sides of the substructure at the same time, but merely demonstrates the proper location to install cable, relative to the substructure wall.

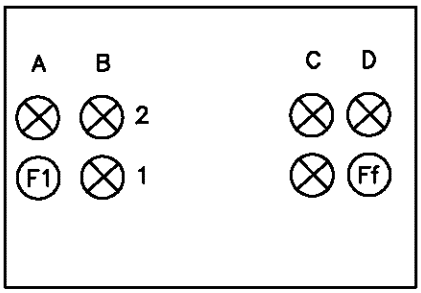
LEGEND

F1 – Feeder (first installed)
F2 – Feeder (second installed etc.)
Ff – Feeder (future, as specified by Electric Distribution Planning)
Fs – Feeder (spare, installed on conversions for ease of future construction)
L – Local Distribution
X – May be occupied by future local distribution

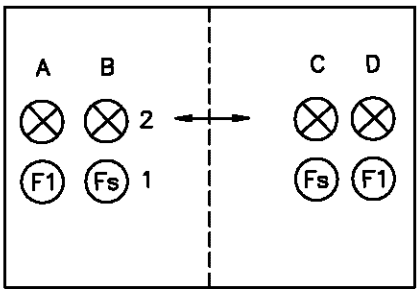
1. 3315 HANDHOLE



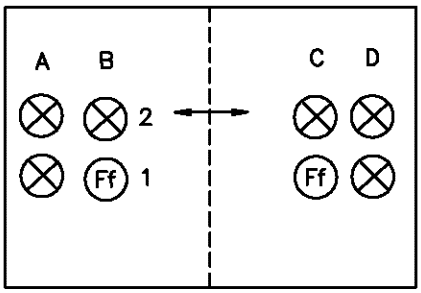
1–FEEDER



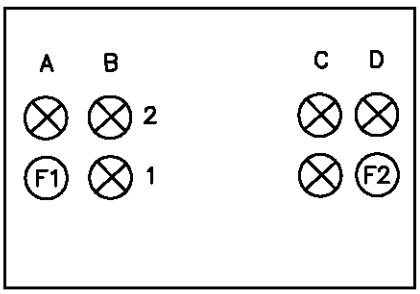
1–FEEDER & 1–FEEDER (FUTURE) *



1–FEEDER & 1–FEEDER F. SPARE



1–FEEDER (FUTURE)



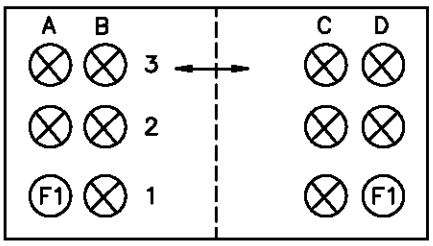
2–FEEDERS *

* Use a 3316 handhole when installing two feeders or one feeder + future feeder with distribution cable.

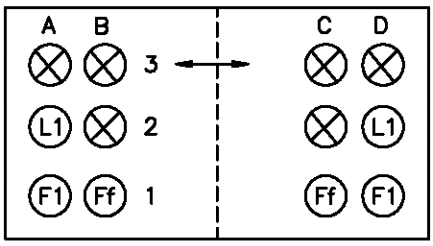
Special Note: One set of 600 amp tees, in most cases, is all that is allowed on one wall of a 3315 handhole. Careful attention should be paid not to exceed the allowable 3315 connection/cable combinations as indicated on Underground Standard 3649.9 thru 3649.14.

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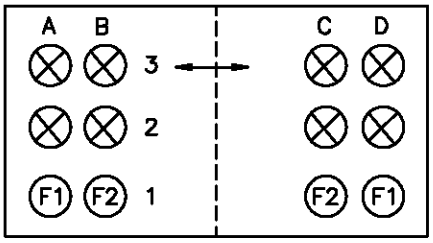
2. 3316 HANDHOLE



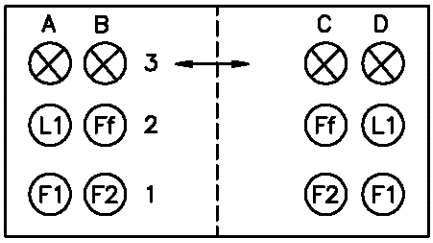
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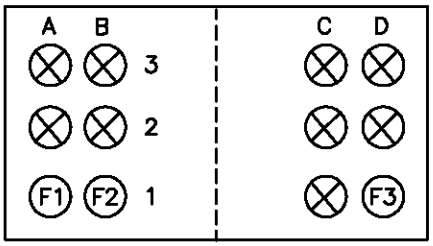
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& 1–LOCAL



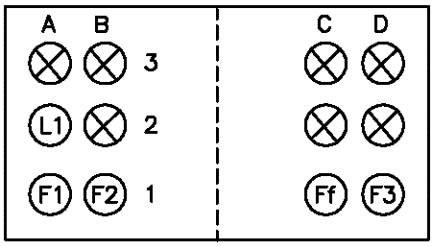
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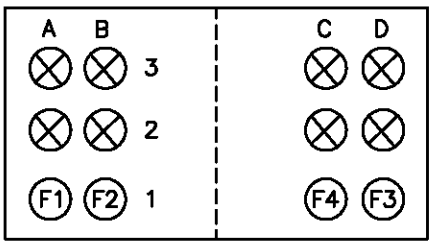
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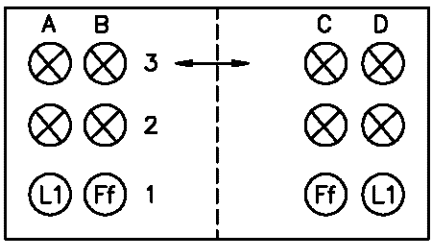
3–FEEDERS



3–FEEDERS, 1–FEEDER (FUTURE)
& 1–LOCAL



4–FEEDERS



1–FEEDER (FUTURE)
& 1–LOCAL

3. 3317 HANDHOLE

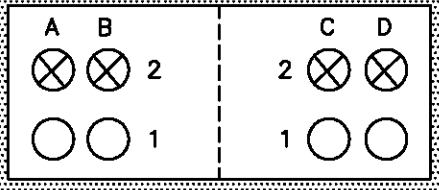


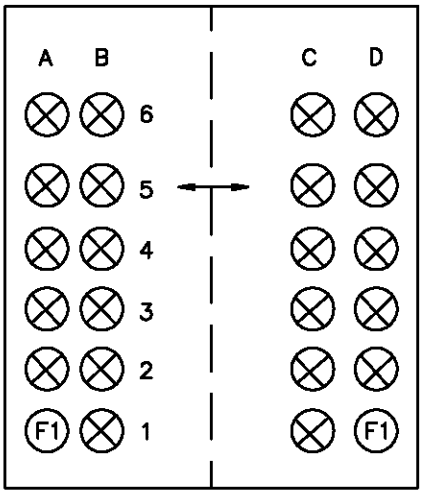
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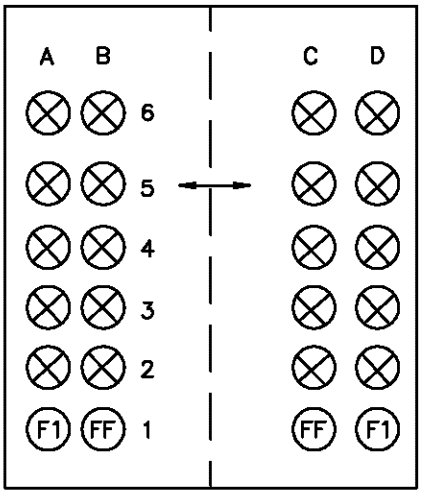
5721.4	SDG&E DISTRIBUTION DESIGN MANUAL CONDUIT POSITIONING WITHIN SUBSTRUCTURES	REVISION DATE 3–1–02 APPD JCE / VCL

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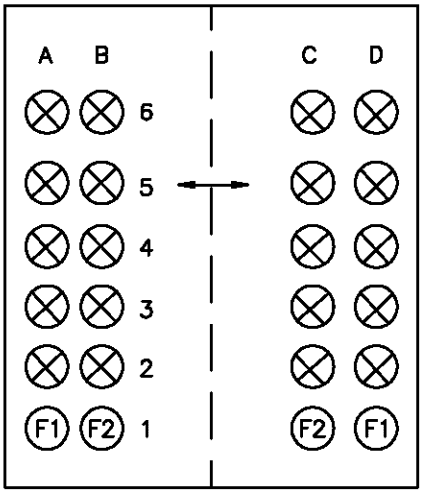
4. 3324, 3325, 3326 MANHOLE:



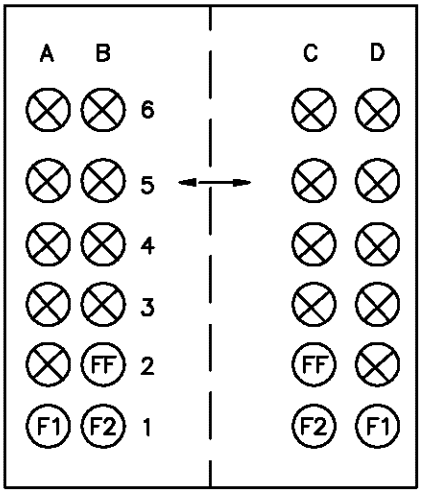
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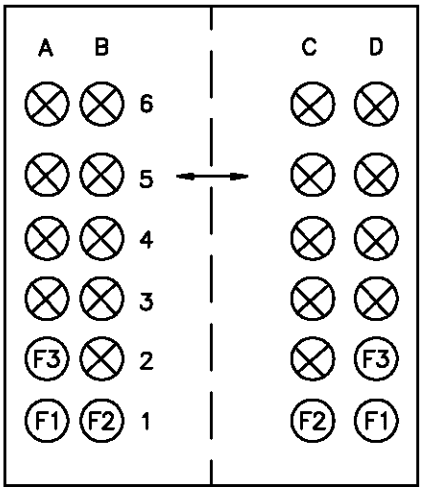
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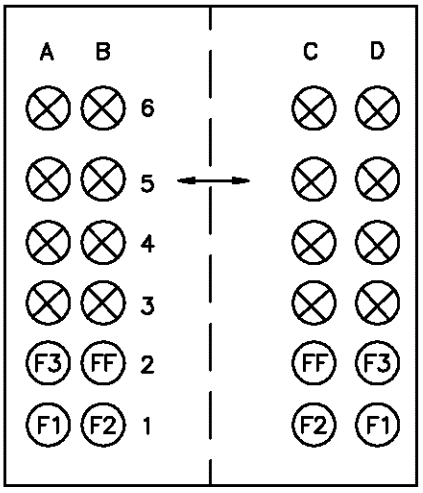
2–FEEDERS



2–FEEDERS & 1–FEEDER (FUTURE)



3–FEEDERS



3–FEEDERS & 1–FEEDER (FUTURE)

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References:

1. Design Standard 5711, Conduit and Substructure Selection Criteria
2. Construction Standards Section 3600, Subsurface Sectionalizing Equipment
3. Construction Standards 4004, Minimum Bending Radius For UG Aluminum.

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SCOPE

This design standard defines the material properties, dimensions, and performance criteria for conduit systems in the electrical distribution system. It specifies acceptable conduit types (PVC & steel), wall thickness classifications (Schedule 40 and 80), and installation methods for Direct Burial, Encased Burial, and above-ground configurations, like risers. These guidelines ensure system integrity, cable protection, and long-term reliability under varying conditions.

DEFINITIONS

Concrete Encasement "Encased Burial" (EB) Conduit – Rigid conduit installed underground and fully surrounded by concrete to provide mechanical protection, structural support, and durability. The conduit is installed within a trench or duct bank and encased with concrete on all sides, with a specified minimum concrete cover.

Direct Burial (DB) Conduit – Rigid conduit installed underground and surrounded by native soil, sand, or select backfill, without concrete encasement.

Electric Distribution Planning (EDP) – Governing entity responsible for overseeing SDG&E's primary electric distribution system.

Polyvinyl Chloride (PVC) – A rigid thermoplastic material commonly used for electrical conduit, valued for its corrosion resistance, electrical insulation properties, and ease of installation in Direct Burial and Concrete-Encased applications.

Rigid Conduit – Conduit manufactured from rigid, non-flexible material composed of suitable nonmetallic or metallic material that provides mechanical protection for electric distribution cables.

Schedule 40 & Schedule 80 – A standardized wall thickness classification for pipes and PVC conduits. It is part of the ANSI/ASME pipe schedule system, which defines wall thickness based on nominal pipe size (NPS). The higher the schedule number, the thicker the wall.

Spare Conduits – Refers to empty conduit(s) as specified by the EDP or a Distribution Designer for areas with growth potential to meet operating and maintenance requirements.

CRITERIA

A. Materials

1. Schedule 40 and Schedule 80 PVC Conduit: This conduit shall be used for below ground applications. A rigid conduit can be characterized as having a relatively heavy wall thickness that is suitable for those applications requiring added strength.
   a. Use Schedule 80 conduit for the first 8-foot on the cable poles risers, per G.O. 95 Rule 54.6 (E)(1) and California Code of Regulations, Title 8 Section 2828. Then switch to Schedule 40 for the remaining riser and conduit sections (see UG4204.2).
      1) 3-inch Schedule 80 type conduit for this section (see UG4204.2 for illustration).
      2) 2-inch PVC conduit is reserved for TELCO and communication lines only, or for use only with existing 2-inch stubs. All new construction should be 3-inch minimum (See UG3373.2).
2. Concrete Encasement (EB) and Direct Burial (DB) Conduit – These conduits are suitable for below-grade applications only and must be of type Schedule 80 and Schedule 40 or other EDE approved equivalent conduits; required for safety and further protection in the event of a dig-in.

B. Rigid Conduit Guidelines

1. Rigid Plastic Conduit
   a. Until it is depleted, Rigid plastic DB40 or DB100 conduit shall be used whenever it is Direct Buried or in cases that do not require EB conduit (Section B.2) or steel conduit (Section B.3). Once depleted, Schedule 40 or Schedule 80 PVC should be used for Direct Buried.
   b. Flexible conduit, corrugated duct, or innerduct systems are not considered rigid conduit unless explicitly approved by Electric Distribution Engineering (EDE).
2. Concrete Encasement (EB)

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a. Concrete encasement of the conduit is required for the following:

1) 5-inch and greater conduit to be encased.

2) Conduit on Port District land.

3. Steel Conduit / Bridge Conduit

a. Exposed conduits attached to a bridge shall be galvanized steel conduits or PVC-coated galvanized steel conduits. Expansion or flexible couplings shall be used to transition to and from the attached conduit ends on the bridge. The conduits must be grounded at both ends of the bridge using 2 (two) separate 8-foot driven ground rods spaced 6-foot apart, per G.O. 95 requirements. The conduits and the conduit support frames (brackets) are long lead time items as they special order items.

b. Contact SDG&E's Civil/Structural Engineering team for design and specifications. Approval to attach conduits to bridges is required from Caltrans, County, City, Municipality, etc.

4. Spare Conduits

a. Below are recommendations, but limited, when considering spare conduits. See DM5229, Underground Cable Installation Criteria for additional details.

1) All Primary conduits should be at a minimum of 3-inch.

2) In all new feeder construction, a minimum of one spare conduit per circuit is required.

3) When requested by a customer at their own expense, but not to exceed conduit limitations in this standard.

4) Based on future construction limitations such as beneath bridges, roadways, and railroad tracks, but not to exceed conduit limitations in this standard.

5) Specified by either the planner or distribution planning for future load growth.

6) In conversion or new business projects to allow easy bypass of the pole during removal. Conduits installed for this purpose shall extend past the pole by a minimum of 6-foot.

7) When installing spare conduits on cable poles do not exceed the limitations as expressed and illustrated in UG4204, Cable Pole Riser Installation.

C. Conduit Application

1. Feeder Conduits

a. EDP is responsible for providing the present, ten-year, and ultimate primary feeder requirements for underground distribution installations. No future conduits shall be specified by EDP that are not supported by the long-term feeder arrangement plan.

b. Distribution designers will specify the number of feeder conduits on the construction work order according to the ultimate feeder requirements indicated by EDP.

1) All feeder conduits are to be at minimum 5-inch.

2) When concrete encasement is required, the concrete-encased portion of the duct bank should contain an even number of conduits only when two-sack concrete is applied. This will reduce the cost associated with pouring concrete where the conduit would normally be placed. Leave an odd number of conduits in the ducts if one-sack concrete is used for encasement.

c. EDP or the Distribution Designer are responsible to provide the final distribution conduit configuration and circuit configuration for every duct package.

1) A minimum of two (2) 4-inch Local Distribution conduits shall be installed in conjunction with any Feeder conduit installation; a reduction to one (1) 4-inch Local Distribution conduit may be permitted only through an approved Deviation Request with concurrence from EDE and/or the Distribution Designer.

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2) Cable ratings are based on conduit and circuit configuration and shall be determined by Electric Distribution Planning (EDP).

NOTE: If an emergency rating is required to support operational needs, EDP shall determine and provide the applicable temporary emergency rating.

2. Lateral or Branch (Local Distribution) Conduits

a. The lateral conduit(s) are required to support the following:

1) Present and future fusing. Paralleling the feeder with a lateral conduit will minimize the number of fuse cabinets required throughout the project.

a) When Local Distribution conduit is installed between Distribution structures, one (1) 4-inch Local Distribution spare conduit shall be included as part of the conduit package. Consult the Distribution Designer and/or EDE for clarification.

2) Looping.

3) Design considerations, such as future loads.

NOTE: If lateral conduits are not required to support the situations listed above, and the need for future local distribution seems unlikely such as in a completely developed area or in areas where ordinances will likely prevent future development (i.e., parks), an exception may be warranted, but will require EDP approval.

b. Local Distribution Work Only

1) All primary laterals conduits shall be at a minimum of 3-inch.

2) Distribution designers should include lateral conduits on new distribution installations. If there is growth potential that may require 2/0 or 3/C-#2 aluminum cable, then a 4-inch conduit shall be specified.

3. Service Stubs

a. If services are not installed at the time the distribution system is installed, rigid conduit stubs will be installed to the property line. It shall be the responsibility of the developer to provide and install the extension of rigid conduit to the building.

D. Conduit Sizing

1. Horizontal bends (primary, secondary & services) in the conduit shall be made only with long sweeps of a 25-foot radius or larger whenever possible. Smaller radius sweeps may be installed only if space limitations prohibit the use of the 25-foot radius sweeps and pulling tensions permit (e.g., short-side services in a subdivision). Should field conditions warrant a smaller radius, approval must come from both the Distribution Designer and the SDG&E Inspector.

2. Secondary and service conduits should be chosen based on the larger of the following cable requirements:

a. Sized according to applicable Underground Construction Standards.

b. Sized according to the cable selection.

E. Abandonment or Removal of Conduit

1. Abandonment or removal of facilities should be documented on work orders when they are no longer in service. Federal Energy Regulatory Commission accounting rules require that they be removed from plants in service. The conduits found on the GIS asset maps are kept current in the GIS database via work order documentation. Underground conduit that is abandoned or removed can be documented by using the generic Compatible Units (CU's) found in SAP/Construction Planning Design (CPD). The size and number of these conduits can and should be specified by using the CU notes feature available with the Design by Location (DBL) locations.

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2. Abandonment or removal of the conduit is not standard practice, especially for conduits in the franchise area. In general, conduits should not be abandoned or removed unless future use can be completely ruled out or when customers need to vacate a private property for development. Empty conduits should not be considered for abandonment or removal simply because they're empty. Before abandoning or removing a conduit, check in with EDP.

NOTES

1. It is not economical to have an even number of EB conduits (either feeder or feeder plus local distribution) in one-sack concrete encasement simply to displace concrete.
2. Concrete encasement may be required for conduits installed at reduced depth (see UG3370).
3. Concrete encasement (one-sack mix) is required for stacked conduits.

REFERENCES`

I. California Code of Regulations, Title 8, Section 2828 Risers

II. General Order 95 Rule 54.6 (E)(1), Risers

III. Electric Distribution Design Manual 5229, Underground Cable Installation Criteria

IV. Underground Construction Standard 3370, Underground Distribution (UD) Trenches and Utility Positioning - S.D. County

V. Underground Construction Standard 4204, Cable Pole Riser Installation

VI. Underground Construction Standard 3373, Conduit and Conduit Fittings – EB & Polyethylene

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SCOPE

This design standard provides the criteria and a standardized method for diagramming substructure details on work order sketches.

DEFINITIONS

- Destination Substructure – The substructure (pad or handhole) where the conduit or conduit package will be terminated.
- Conduit Termination Designation – A specific conduit knockout position on the destination substructure where the conduit will terminate, to be used only when it is not clear where conduit(s) will terminate or when rolling/swapping multiple conduits.
- Conduit Package – Considered to be two or more conduits originating and terminating together.
- Conduit Callout – The identification of conduit size, cable size, circuit, destination substructure, equipment designation, and conduit termination designation for a particular conduit knockout or conduit package.
- Equipment Designation – A specific type of pad-mounted equipment where the conduit will terminate.

CRITERIA

A. Substructure detail diagrams should be provided on work order sketches for all handholes and manholes and substructures located under pad-mounted switches. The substructure detail provides vital conduit/cable installation information for construction and reference information for future extensions.

B. When placing substructure details on the work order sketch, the orientation should be the same as the substructure it is illustrating.

C. Each conduit callout should include the following:

1. Conduit size (whether occupied by cable or spare).
2. Cable size and number of conductors: e.g., 3-1000, 2-#2.
3. Circuit number: e.g., Circuit# 273, Sectionalizing.
4. Destination substructure identification: e.g. D123567, H109145.
5. Equipment designation (applicable to pad-mounted equipment). See item D.
6. (Optional) Conduit termination designation: e.g. A1, A2, A3, B1, etc. This should be used only when it is not clear where conduits are to terminate or when rolling/swapping multiple conduits.

D. Equipment Designations

Pad-Mount Device	Designation
Transformer	STA
Fuse Cabinet	FC
Terminator	TERM
Switch	SWI
Capacitor	CAP
Service Restorer	SR
SCADA Pad	SCP
Molded Vacuum Interrupter or Switch	MVI or MVS
CLEER	CLEER

E. Refer to DM5721, Conduit Positioning Within Substructures.

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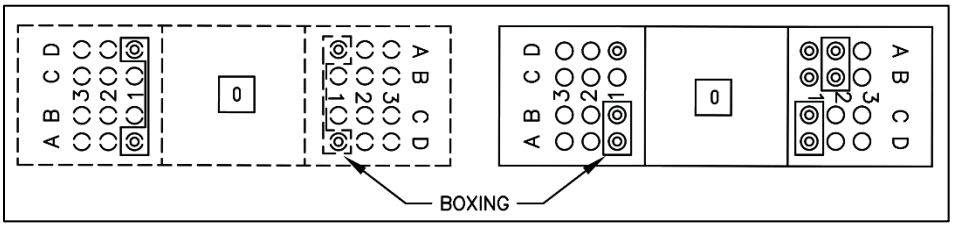
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F. Refer to DM5722, Conduit Application.

G. When providing substructure details on work orders, indicate whether the substructure is existing (dashes) or new (solid). Both existing and new conduit callouts should be provided in substructure detail.

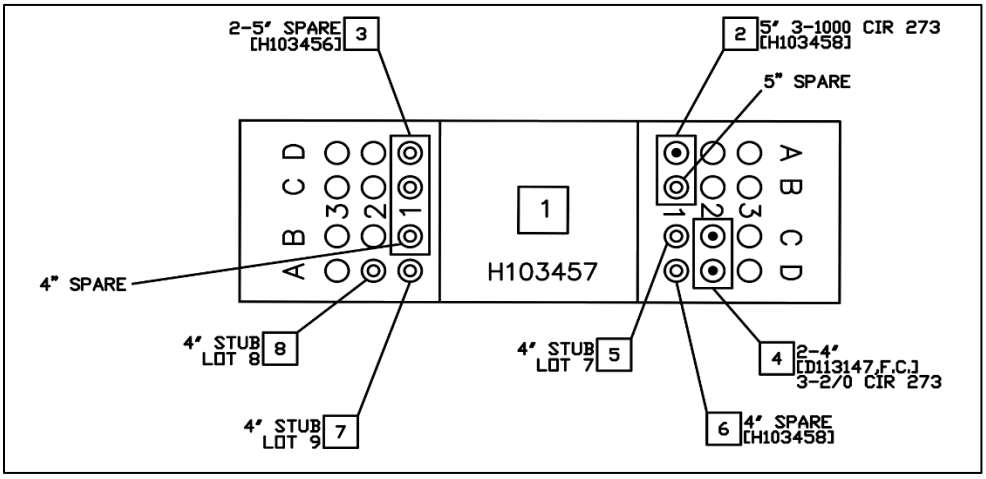
H. Conduit packages that originate and terminate as a package should be indicated on substructure detail by boxing.

Example of Boxing

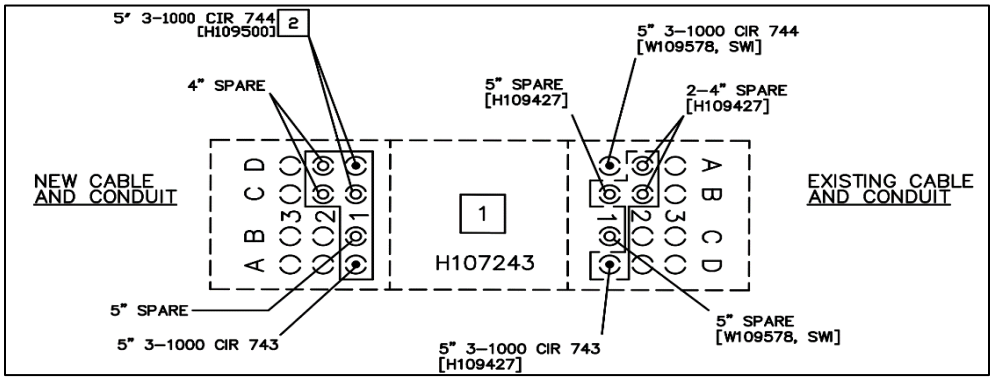


I. The following are examples of the proper method for diagramming substructure details:

New Substructure



Existing Substructure



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J. The following substructure details show the method for detailing conduit placement from one substructure to another.

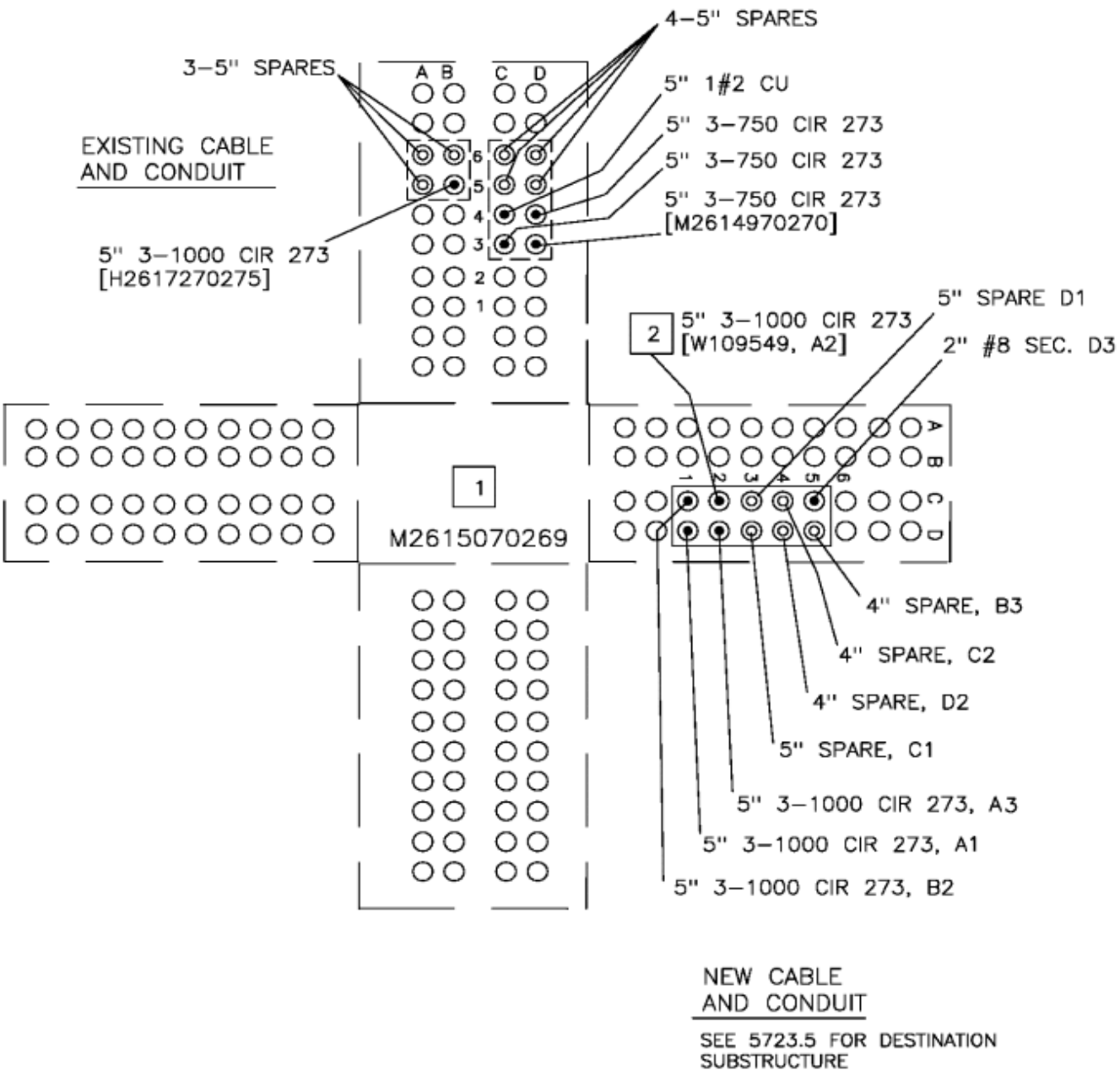


Figure 1

Existing Substructure (Originating Substructure)

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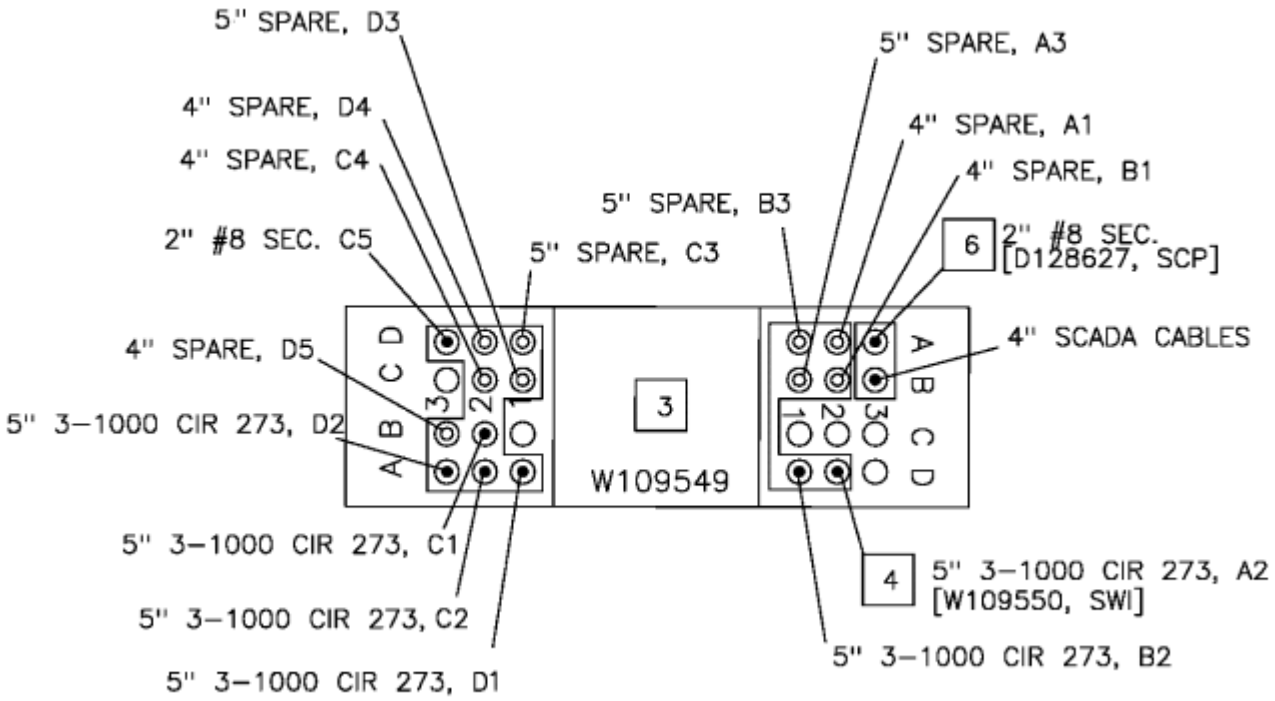


Figure 1

New Substructure (Destination Substructure)

REFERENCES

I. Design Manual 5721, Conduit Positioning Within Substructures

II. Design Manual 5722, Conduit Application

III. Underground Construction Standards Section 3500, Pad & Wall Mounted Sectionalizing Equipment

IV. Underground Construction Standards Section 3600, Subsurface Sectionalizing Equipment

V. Service Planning Manual 1085, Design Sketch

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SCOPE

The following design standard has been developed to assist distribution designers and field review personnel in determining whether an electric underground construction job is a good candidate for directional bore.

DESCRIPTION

Trenchless installation of electric conduits can be accomplished using non-directional and directional boring techniques. Non-directional tools, such as pneumatic piercing tools (moles), are used to install single conduits, usually for short runs. Installations of multiple ducts are generally done using directional boring machines, which are electronically trackable and steerable to avoid any underground obstacles and existing utilities in their path. During the directional bore, a mixture of bentonite clay and water is emitted through small diameter jets in the rod, allowing it to work its way through the soil, stabilize the trench wall, and lubricate the conduit (poly-pipe) during pullback.

APPLICATIONS

A. Street crossings are ideal candidates, but it is not just limited to this scenario (refer to Underground Construction Standard 5000, Trenchless Construction for further details). Lateral installations will be considered on a job-by-job basis.

B. Primary or secondary installations.

C. Single duct installation – 2in through 5in conduit.

D. Multiple Ducts:

1. Up to 2 – 5" conduits
    a. For 4 – 5" conduits, trenchless technology installations of 4 – 5" conduits are to be limited to areas where there are minimal underground utility conflicts and heavy underground path congestion. There shall be no trenchless installation of 4 – 5" conduits or more near substations.
2. Up to 3 – 4" conduits
3. Up to 4 – 3" conduits
    a. For 3" – 4" conduit installations, other combinations are possible. Contact EDE.
4. Up to 5 – 2" conduits
    a. 2" conduit is only applies to SCADA installations or connecting to an existing 2" primary stub. Other than these two scenarios, a Deviation Request is required.

OTHER CONSIDERATIONS

A. Coiled or Straight Length Conduit:

1. Polyethylene coiled conduit is available in 2" and greater sizes.
2. Straight lengths are allowed for 5" or larger conduit due to handling constraints.

B. Coming In or Out of Substructures:

1. There are currently no special fittings for polyethylene (PE) installations to substructures.
2. It is recommended that a polyvinyl chloride (PVC) stub be left sticking out of the substructure, where the PE will transition from the PVC stub using mechanical couplings.

C. Conduit Transitions:

1. Mechanical couplings should be used for any transitions from PVC to PE and vice versa.

D. Soil Conditions:

1. Difficult soil conditions and easements may not allow for a directional bore application.

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2. Difficult soil conditions may slow down a job or force the job to be done using open trench methods.

REFERENCES

I. Underground Construction Standard Section 5000, Trenchless Construction

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SCOPE

The design standard establishes the specifications for the installation of SDG&E distribution facilities in a customer-owned vault. The information provides requirements to be followed for the construction of the vault and installation of electrical equipment per SDG&E standards.

REFERENCES

Electric Distribution Design Manual 5745, Electric Vault Design Tables for SDG&E Internal Use

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The following specifications have been compiled for the installation of SDG&E distribution facilities in a customer-owned vault. The information provides requirements to be followed for the construction of the vault and installation of electrical equipment per SDG&E standards. Consult the appropriate regional Project Management Office/Service Center for approval whenever any alteration to or deviation from these plans and specifications are contemplated. See service center and phone number listed below.

This installation must comply with all applicable rules of the Electrical Safety Orders of the Division of Industrial Safety, Department of Industrial Relations, State of California, National Electric Code, California Code of Regulations Title 8, CPUC General Order 128, and other governing codes and ordinances.

PROJECT TITLE: _____

PROJECT LOCATION: _____

PROJECT NUMBER: _____

SERVICE CENTER: _____

PHONE NUMBER: _____

PLANNER: _____ DATE: _____ APPROVAL: _____

SUPERVISOR: _____ DATE: _____ APPROVAL: _____

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CUSTOMER SHALL FURNISH, INSTALL, OWN, AND MAINTAIN:

1. TRANSFORMER VAULT:

1.1. Walls, roof, and floor shall be assemblies of materials approved for three-hour non-combustible fire resistive construction (California Code of Regulations, Title 8, Section 2806). All walls to be solid or solid filled. All concrete block or brick joints to be solid mortared. All floor-to-wall joints, wall-to-wall joints and wall-to-ceiling joints to be sealed water-tight with water- and oil-resistant materials. Street grade vaults only require sealing of floor-to-wall joints and wall-to wall joints to a height of 6-inches above floor, with water- and oil-resistant materials.

1.2. A 6-inch threshold for oil retention shall be provided at all vertical access openings into vault. See Section 22.

1.3. Vault size _____ (inside dimensions). See Section 24 for dimension table.

1.4. Whenever a vault is constructed over sublevels of a structure, the customer is to provide SDG&E with a certificate from a licensed civil engineer registered in the State of California verifying the structural adequacy of the building to support the transformers and the fire withstanding capabilities of the structure's floor, ceiling and walls. Vault floor to be capable of supporting combined equipment weight of _____ lbs.

1.5. Any vault construction below finished grade is to be considered a dry vault. The exterior surfaces of a dry vault which are exposed to surrounding earth conditions shall be sealed water-tight with an impermeable seal to prevent water entry through any portion of the vault. See Section 1.1 above for sealing requirements for wall, floor and ceiling joints.

1.6. No ducts, pipes or conduits, except those which are a part of the electrical installation shall be installed in or through the vault. Sprinklers and smoke detectors shall not be installed in the vault room.

1.7. All conduits passing through vault floor or walls (see Section 1.6 above) shall be sealed water-tight with water- and oil-resistant materials on exterior surface. In addition, the customer must apply a 1-inch thick and 1-inch-wide layer of sealant mastic around the conduit in the center of the form before concrete is poured. See **SDG&E Underground Construction Standards 3960** for illustration of required technique, recommended materials and required spacing between conduits. Contact SDG&E inspector at least one (1) business day in advance of concrete pour to schedule inspection of construction of vault walls through which electric conduit pass.

1.8. All spare conduits between the vault and a substructure located outside the vault shall be plugged at both ends with expandable duct plugs.

1.9. Customer shall inform SDG&E when any prestressed concrete portions of vault are proposed for construction.

2. PERSONNEL ACCESS DOOR (WALK-THROUGH DOOR):

2.1. Customer is to provide a 3ft. x 6ft-8in., three-hour fire-rated self-closing personnel access door equipped with panic hardware, and should be located as shown in Section 22 or 23.

2.2. Customer is to provide light switch, with lighted switch plate, inside vault and adjacent to door.

2.3. Customer is to install **weather strips on all door edges** to prevent excessive air intake around door edges when vault ventilation is operating, and to limit fresh air intake in case of fire.

2.4. Customer shall provide and install a Schlage VTQP section MA series key section in a storeroom function (self-locking) Rhodes series lever action lockset. SDG&E will replace the MA series cylinder with an electric series cylinder prior to energizing the service. The customer is required to notify SDG&E's inspector when the lockset is installed.

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2.5. Personnel access door shall open into a clear area that will allow manual carry-in of small tools and equipment. Personnel access doors in garage areas shall open into a designated no-parking zone and have permanent unobstructed access to the door.

2.6. Door threshold shall be 6-inch above vault floor for oil retention. All threshold seams, if any, to be sealed with water- and oil-resistant materials. See "Equipment Openings in Vault Wall" illustration in Section 22.

2.7. Customer to attach sign/placard to door stating the following:

2.7.1. "SDG&E Electric Vault", "Danger – High Voltage – Keep Out."

2.8. Customer to provide SDG&E with an approved route with 24-hour access easement to the personnel access door in the vault. If an electrically operated gate is installed restricting SDG&E vehicle access to the walk-through door, customer shall install an SDG&E approved Schlage VTQP quad section cylinder in a key switch wired to the gate controller. A list of locksmiths authorized to sell SDG&E approved locks is available on request. The customer will install a means of opening the gate from the inside without the use of a vehicle to activate the controller. This will require the installation of an additional key switch inside the gate if there is no unsecured switch available. Door to have 24-hour direct ingress and egress for SDG&E personnel.

3. EQUIPMENT OPENINGS:

3.1. At Grade Vaults:

3.1.1. 8ft. x 10ft. Equipment opening through exterior vault wall. Equipment access door shall be three-hour fire rated and have 24-hour direct access for SDG&E personnel. Customer shall provide and install a Schlage VTQP quad section MA series key section. SDG&E will replace the MA series cylinder with an electric series cylinder prior to energizing the service. A permanent and level 6-foot clear working area, at least as wide as the door, is required outside of the equipment access door and at the same grade as the vault floor.

NOTE: For a custom door size please consult the appropriate regional Project Management Office/Service Center for approval whenever any alteration to or deviation from these plans and specifications are contemplated

3.1.2. Customer to install removable 6-inch oil retention sill at equipment opening floor level when there is no other access for installing or removing transformers or other vault equipment. Sill construction to be 6-inch steel box beam. Bolts to pass through beam and align with inserts embedded in base of equipment opening. The beam must align with floor base and vertical edge to provide close fit for sealant compression to retain oil inside vault. Sealant to be oil and water resistant. See Section 22.

3.2. Below Grade Vaults:

3.2.1. 10ft. x 10ft. Equipment opening through vault ceilings. Customer shall provide removable 3-hour fire rated 3-part concrete cover with wheel load factor HS-20 (per AASHTO). Customer to submit drawings approved by licensed civil engineer registered in the State of California verifying HS-20-wheel loading for each equipment opening cover. No section of covers to exceed 4,800 lbs. Both opening and cover(s) shall have matching beveled edges, with 30° vertical deflection. Four lifting coil inserts to be provided for removal of each section of cover. Lifting inserts shall be 1-inch threaded coil inserts with 4,500 lbs. safe working load tension. See Section 23: Electric Vault Location and Accessibility for illustrative details for equipment opening 3-piece cover. The equipment opening must be kept clear and unobstructed by customer- installed equipment both above and below the opening. A minimum vertical clearance of 30-foot - for operation of heavy equipment including cranes - must be provided above the equipment opening - see illustration in Section 23. Customer shall seal the cover to prevent water entry following installation of equipment. Repair, maintenance or replacement of

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any old or new, damaged covers is the responsibility of the customer. SDG&E will inspect routinely and determine when replacement is necessary.

3.2.2. Customer to provide personnel access opening with 30-inch cast-in-frame ring and a 34-inch cast iron cover. Opening to be adjacent to equipment opening and at final grade. No coverings are permitted over this opening. Locate opening as shown in Sections 22.2 & 25. See SDG&E Underground Construction Standards 3332.

3.3. Truck Access on Private Property: If both the equipment opening and access route to equipment opening is located on private property, customer will provide permanent "all weather" drivable access route to equipment opening. This permanent access route shall be of sufficient strength to support truck weight class HS20 (20 tons per axel), be a minimum of 16-foot wide and 13ft-6in high, with permanent turnaround having 20-foot minimum turning radius – as measured from inside radius edge. Customer may provide permanent drive through access route in lieu of turnaround if so desired. Customer to install "Permanent SDG&E Truck Access Route" placard along access route with a minimum of one placard every 25-foot. If heavier duty equipment is used to install facilities, such as a large crane, permanent access shall be maintained.

3.4. Truck Work Area on Private Property: If equipment opening is located on private property and area in immediate vicinity of equipment opening is also located on private property, customer will provide clear and permanent truck work area at least 50ft. long x 16ft. wide, centered on equipment opening.

3.5. Truck Access in Public Right-of-Way: If equipment opening is adjacent to public right-of-way, or in public right-of-way, it shall be located such that it provides the same truck access as for private property.

3.6. Truck Work Area in Public-Right-of-Way: If equipment opening is adjacent to public right-of-way, or in public right-of-way, it shall be located such that it provides the same truck work area as for private property.

3.7. Boom Clearance: Customer will provide permanent overhead boom clearance at equipment access opening as shown in "Electric Vault Location and Accessibility" illustration in Section 23.

3.8. Restrictions: Customer is not permitted to install tables, chairs, partitions, posts, signs, screens, walls, fences, railings, or barriers of any nature above or in front of SDG&E equipment opening or personnel access opening into electric vault.

4. PULLING INSERT REQUIREMENTS:

4.1. Transformer/switch/equipment moving inserts (A) – _____(no.) 1-inch diameter galvanized pulling irons located 48-inch up from vault floor, per attached SDG&E sketch. The coil insert strength shall be 10,000 lbs. minimum with a working load safety factor 3. The concrete vault shall have a safety factor of 2 for these loads.

4.2. Cable pulling insert (B) (below grade vaults) – One 7/8-inch diameter galvanized pulling iron(s) located in the opposite wall and at same height as incoming conduits. Pulling iron(s) to be designed to provide a minimum pulling tension of 12,000 lbs. The concrete vault to have a safety factor of 2 for these loads. A clear and unobstructed path must be provided and maintained between the conduit opening (into the vault) and the pulling eye on the opposite wall.

4.3. Cable pulling insert (C) (below grade vaults) – One 1-inch diameter galvanized pulling iron in same wall as cable pulling insert required in Section 4.2 above, located directly opposite equipment opening, 48-inch above the vault floor. Pulling iron to provide a minimum pulling tension of 12,000 lbs. The concrete vault to have a safety factor of 2 for these loads. A clear and unobstructed path must be provided and maintained between cable pulling insert in Section 4.2 and this cable pulling insert.

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4.4. Cable pulling insert (E) (on grade vaults) – One 1-inch diameter galvanized pulling iron located in vault ceiling directly above incoming conduits in vault floor. Pulling iron to provide a minimum pulling tension of 12,000 lbs. The concrete vault to have a safety factor of 2 for these loads.

4.5. Optional cable and/or transformer insert – May be located in the vault floor a minimum of 9-inch from any wall face and located per attached work order sketch.

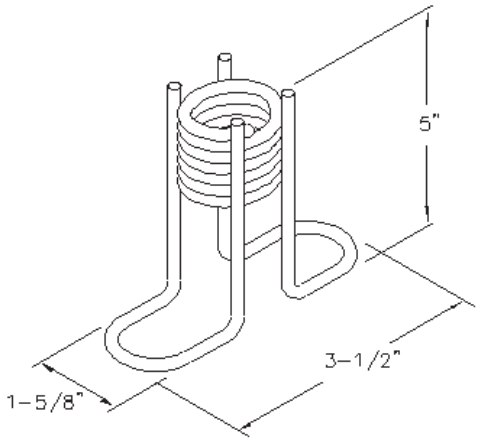


Figure 1: Typical Coil Insert for Use into Thin Slabs or Small Sections

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5. VENTILATION SYSTEM:

5.1. Ventilation openings shall be located as far away as practicable from building doors, windows, fire escapes and combustible material (California Code of Regulations, Title 8, Section 2806). Openings inside the vault shall be located to direct the air stream over and around the transformer(s).

5.2. Supply Air (Intake) Opening for supply air shall be provided from a source of clean outside air or garage air. Intake louver(s) shall be provided on the outside of the building or in the garage, located at a minimum of 18-inch above grade and per local codes. Intake louver(s) shall be sized according to the louver manufacturer's recommendations to minimize entrainment of water into the air stream. Intake louver(s) shall be provided with bird screens. 3-hour fire-rated ductwork shall connect the intake louver(s) to the vault. Ductwork shall be sized and designed per SMACNA, ASHRAE, and industry standards. Ductwork sizing should consider pressure drop, air velocity and noise. Supply air opening(s) shall be located away from exhaust louver(s) and at least 18-inch above the floor of the vault and positioned to promote good cross ventilation/distribution of supply air across the entire vault. Supply air openings shall be constructed with a 1/2-inch mesh hardware cloth and sized for a maximum face velocity of 800-foot per minute. In addition, the foregoing installation is to comply with all local codes and ordinances.

5.3. Exhaust Air (Discharge): Ventilation and cooling air from the vault shall be discharged to the outside of the building or garage through exhaust louver(s). Exhaust louver(s) shall be located a minimum of 18-inch above street grade, away from intake louver(s) and building openings and per local codes. Exhaust louver(s) shall be sized per the louver manufacturer's recommendations. Exhaust louver(s) shall be provided with bird screens. 3-hour fire-rated ductwork shall connect the exhaust louver(s) to the vault. Ductwork shall be sized and designed per SMACNA, ASHRAE, and industry standards. Ductwork sizing should consider pressure drop, air velocity and noise. Exhaust opening(s) shall be located near the ceiling of the vault and positioned to promote good cross ventilation and/or distribution of supply air across the entire vault. Exhaust openings shall be constructed with a 1/2-in mesh hardware cloth and sized for a maximum face velocity of 800-foot per minute. In addition, the foregoing installation is to comply with all local codes and ordinances.

NOTE: General formula for estimating ventilation air flow, CFM, through vault: 3 x KVA of transformer capacity = CFM, Cubic Feet Per Minute. CFM should not exceed 800 cubic feet per minute.

5.4. Ventilation fan motor must be located inside transformer vault. Coordinate with SDG&E to determine acceptable location prior to purchase of equipment. Ventilation fan motor installation is to comply with all local codes and ordinances.

5.5. Ventilation fan motor inside transformer vault shall have a disconnect device located (and marked) inside the vault adjacent to personnel access door. Customer to provide thermostat control, with a range of 70°F to 140°F located inside the vault mounted away from intake and exhaust vents in easily accessible location. **Customer to provide regular scheduled maintenance for ventilation fan motor. Coordinate with SDG&E for access to transformer vault.**

5.6. Fire dampers shall be installed as required by local and State governing agencies having jurisdiction for the Occupancy type for the building. Any required fire dampers are to be located within vault. Provide adequate clearance for fire damper installation on supply & exhaust vent openings if dampers are required.

5.7. One continuous____CFM (minimum) exhaust fan direct driven by a_____three-phase, sealed ball bearing motor. Fan to be mounted as close to the ceiling as practicable.

5.8. Vents, ducts, and flues shall not be connected to any other ventilation or air distribution system and must be for exclusive use of electric (transformer) vault.

5.9. See Section 21 for Internal Vault Wiring Diagrams.

NOTE: No gas meter set assemblies are allowed within 10-foot of intake vents.

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6. VAULT LIGHTING SYSTEM:

6.1. Vault light switch and 120V power receptacle. A 277V vault lighting system may be installed if available.

6.2. EXO switch complete with protection. Ventilation blower motor and vault lighting system to be separately protected. See attached detail_____for diagram schematic.

6.3. Customer to wire out per authority having jurisdiction (AHJ) from point adjacent to secondary side of transformer to EXO switch and interconnect vault lights, switch and receptacle, exhaust fan and thermostat control as required.

6.4. Lighting design shall consist of LED lighting system in accordance with applicable IES, NESC and governing agency requirements. Lighting fixtures shall be ceiling-mounted at a maximum height of 9-foot above floor surface at locations indicated on SDG&E drawing.

6.5. See Section 21 for Internal Vault Wiring diagrams.

7. ENERGIZING VAULT VENTILATION AND LIGHTING SYSTEM:

7.1. When initially energizing the vault ventilation and lighting system a joint meeting with the customer journeyman electrician and SDG&E crews shall be scheduled to demonstrate compliance with approved building electrical and mechanical plans and permits, and the full and proper functioning of all, motors, fans, lighting, controls, access and safety equipment in the vault room. For services using three-phase motors, correct phase rotation must be verified before equipment start-up.

8. VAULT DRAINAGE SYSTEM (CHECK WITH CITY IF REQUIRED):

8.1. When Governmental or Municipal authority requires a vault drainage system, the customer is to install a standard floor drain connected to a dry sump located outside of the vault. Slope the floor gently to this drain and cover with standard grating. Customer will be responsible for maintaining all components of drainage system in good working condition.

8.2. The design and installation of vault drainage system (provided by the customer) must be approved by the appropriate inspection authority and must meet all local, state and federal environment requirements for all components.

8.3. Customer is responsible for proper environmental disposal of all liquids recovered by vault drainage system.

8.4. Waste collection container must be capable of containing the total volume of oil for projected maximum size transformer(s) (based on panel size(s)) that can be used in vault. Contact SDG&E for volume requirement.

8.5. Regardless of whether Governmental or Municipal authorities require a vault drainage system, customer will install a sump hole directly below street level personnel access opening - in below grade vaults only.

9. VAULT GROUNDING SYSTEM:

9.1. Trench grounding is the preferred method for providing grounds for all vaults. Customer to install 30-foot of 4/0 bare stranded copper wire in the primary trench closest to building and encase the 4/0 bare copper wire in the base of the trench. See SDG&E Underground Construction Standards 4510. Customer to insert 4/0 ground wire into 1-inch PVC conduit for transition through vault/building wall. See SDG&E Underground Construction Standards 3960 for required technique and materials to transition PVC conduit through concrete. Ground wire inside vault to reach vault floor + 24-inch additional length.

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9.2. As an alternative method, only when the approaching primary trench is less than 30-foot in length, customer to install two 5/8in. X 10ft. long copper clad steel ground rods at minimum 6-foot interval in the primary trench. Install 4/0 bare stranded copper wire ground wire. Rods to be interconnected with 4/0 bare strand copper wire. See SDG&E Underground Construction Standards 4510. Customer to insert 4/0 ground wire into 1-inch PVC conduit for transition through vault/building wall. See SDG&E Underground Standards 3960 for required technique and materials to transition PVC conduit through concrete. Ground wire inside vault to reach vault floor + 24-inch additional length.

9.3. Customer to provide individual equipment grounds within the vault for all transformers, capacitors, cable taps and fuse cabinets as specified by SDG&E. Customer to install/embed 1-#2/7 bare strand copper wire into vault floor for each transformer, capacitor, fuse cabinet and set of cable taps. Equipment ground wire to run from primary side of each transformer or capacitor, from below middle cable tap, and from below fuse cabinet, to a position just below entry point where 4/0 bare stranded copper trench ground wire transitions through vault wall – see Section 9.1 or 9.2 above. Customer to provide 24-inch (minimum) tail at each end of (each) equipment ground wire embedded in the floor of the vault.

9.4. Contact SDG&E inspector at least one (1) day in advance to schedule inspection of installation of trench ground outside vault (prior to backfill) and/or equipment ground embedded in vault floor. Customer to provide ladder access and a safe temporary access path (plywood or planks) within the vault for SDG&E inspector to make the inspection.

9.5. SDG&E will install required interior grounding for switches inside the vault.

10. PRIMARY CONDUIT, EXTERIOR AND INTERIOR:

10.1. Primary exterior conduit trench shall be slurry backfilled, concrete encased or as specified by SDG&E.

10.2. Primary exterior conduits shall terminate in corner of vault as specified by SDG&E Project Management Department. Top of conduit package shall terminate no less than 60-inch below interior surface of vault ceiling.

10.3. All conduits passing through vault exterior wall (see Section 1.6 & 1.7 above) shall be water-tight with water- and oil-resistant materials. Conduit must be sealed on vault exterior surface. In addition, customer must apply a one inch thick and one-inch-wide layer of sealant mastic around each conduit in the center of the form before concrete is poured. See SDG&E Underground Construction Standards 3960 for illustration of required technique, recommended materials and required spacing between conduits. Contact SDG&E inspector at least one (1) day in advance to schedule inspection of vault floor through which conduits pass.

10.4. All conduits passing through vault floor (see Section 1.6 & 1.7 above) shall be sealed water-tight with water- and oil-resistant materials. If possible, conduit may be sealed on vault interior surface. In addition, customer must apply a 1-inch thick and 1-inch wide layer of sealant mastic around the conduit in the center of the form before concrete is poured. See SDG&E Underground Construction Standards 3960 for illustration of required technique, recommended materials and required spacing between conduits. Contact SDG&E inspector at least one (1) day in advance to schedule inspection of construction of vault floor through which conduits pass.

10.5. All primary exterior conduits shall be installed such that they are free and clear of dirt, rocks, or other obstructions. Customer/developer shall install 3/4-inch pulling and measuring tape rated at 2,500 lbs. tensile strength in all conduit runs over 10-foot. Each conduit will have at least a two-foot measuring tape coil securely tied at each terminating end of conduit run. Horizontal conduit bends shall be 25-foot radius of curvature.

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10.6. Contact SDG&E inspector at least one business (1) day in advance to schedule inspection of installation of primary exterior conduit system (prior to backfill).

NOTE: Service conduits not included in this section.

10.6.1. _____ (#. Conduits), _____ In. Size, _____ Type

10.6.2. _____ (#. Conduits), _____ In. Size, _____ Type

10.6.3. _____ (#. Conduits), _____ In. Size, _____ Type

10.6.4. _____ (#. Conduits), _____ In. Size, _____ Type

10.7. Primary interior conduit may be installed beneath the vault floor provided vault floor is located at street level and is completely resting on earth.

10.8. Cable troughs may be installed in vault floor as substitute for primary interior conduits. Customer to submit specification to SDG&E for approval prior to fabrication. Allow 6 inches of width for each set of distribution cables and 7-inch of width for each set of feeder cables. The maximum width of any trough will be 30-inch.

10.9. Trough covers will be designed to withstand a minimum of 20,600 lbs. traffic loading capacity (AASHTO H20 and ASTM C 857). Trough cover surfaces must be smooth textured to allow easy pass-over by small roller wheels. Trough covers will be flush mounted and have flush mounted lifted handles on each end, or 1-inch lifting hole on both ends. Trough cover sections will be limited to a maximum weight of 80 lbs.

10.10. Cable troughs may not pass beneath floor mounted electric equipment. Troughs may terminate beneath floor mounted electric equipment.

10.11. Cable trays may be installed as substitute for primary interior conduits. See Section 15.

11. CUSTOMER SERVICE CONDUIT:

11.1. Service conduits are only permitted when transformer vault is located at street level and vault floor is resting on earth. Combinations of 3 or 4-inch service conduits may be used provided they do not exceed 6 conduits total. A maximum of five 5-inch service conduits may serve commercial & industrial boards up to 2,000A. A maximum of five 5-inch service conduits may serve residential & multifamily boards up to 3,500A.

11.2. In addition to truck access required in section 3 above, line truck access is to be provided as indicated in SDG&E Service Standards & Guide, when service conduits will be installed.

11.3. Service conduit requirements exceeding quantities stated above will require bus duct, rather than conduit, between secondary side of transformer and customer service equipment. When transformer vault is not on street level, and is not resting on earth, bus duct is required between secondary side of transformer and customer service equipment.

11.4. Install_____conduits from secondary side of transformer to customers pull section as indicated on sheet **XX** of **YY**. Terminate primary and service conduits at least 2-inch above floor to permit sealing (see Section 1.6 & 1.7 above).

11.5. When more than one pull-section is served by the same transformer and the total number of conduits exceeds those listed above, bus duct will be required.

11.6. All electric service conduits passing through vault floor shall be sealed water-tight with water and oil resistant materials. See SDG&E Underground Construction Standards 3960 for required spacing and specifications to be provided between conduits to allow use of sealing tools. See Section 1.9 above for additional requirements.

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12. SERVICE ENTRANCE, BUS DUCT:

12.1. Service duct housing from customer's service equipment to transformer should be submitted with switchgear to SDG&E Service Standards for approval. The design and location must be approved by SDG&E prior to fabrication. Refer to attached enclosure for straight bus section and bus entrance box. For attachment to transformer housing, bus bar configuration and transformer housing see illustrations in Section 18 for details/specifications. Bus and entrance box to be permanently supported as required. Horizontal bus sections within vault to maintain 7ft-6in vertical clearance above vault floor. Where bus enters vault room, opening to be sealed following bus installation. Bus ampacity to match or exceed panel rating.

12.2. Customer service entrance installation to comply with all local codes and ordinances.

13. CUSTOMER'S METERING FACILITIES:

13.1. Customer's meter board shall be constructed in accordance with SDG&E's service guide requirements. Manufacturer shall submit drawings to SDG&E Service Standards group for approval prior to fabrication.

14. COMMUNICATIONS CONDUIT:

14.1. SCADA (Supervisory Control and Data Acquisition): One 4-inch communications conduit shall be extended from customer vault to closest SDG&E substructure (for supervisory cable). Or one 4-inch conduit shall be extended to anticipated/future SCADA antenna location (for coax cable). And one 1-inch conduit shall be extended from customer vault to project telephone equipment area (telephone line). Coordinate with SDG&E Project Management Department to determine specific requirement. SCADA work order should be worked with the initial work order that will feed the transformer vault room.

15. CABLE TRAY:

15.1. Customer to submit layout and specifications to SDG&E for approval prior to installation. Design layout, conduit or through of cable trays should adhere to SDG&E Design Standards, equipment clearances, and cable pulling requirements.

15.2. Refer to Article 392 of the National Electric Code (NEC) for guidelines in selecting the proper cable tray type (The type of cable to be installed in the tray will dictate the type of cable tray needed).

15.3. Refer to Article 392 of the National Electric Code (NEC) for guidelines in calculating the cable tray depth and width (The type and number of cables to be installed will dictate the depth and width).

15.4. Cable tray side rail height should be at least 1-inch higher than the load depth (the depth of the largest cable).

15.5. Cable tray radius: The nominal (inside) bending radius for curved sections of cable trays shall not be less than the minimum allowable bending radius for the largest (triplexed) cable to be installed in the tray. Refer to SDG&E Underground Construction Standards 4004 for a listing of minimum cable bending radius.

15.6. Cable tray load/span classification describes the cable tray's load carrying capability for a specific support span. A classification should be selected that reflects the actual working load for each application. Refer to SDG&E Underground Construction Standards 4003 for a listing of SDG&E cable weights.

15.7. Cable trays shall hang not less than 7ft-6in above the vault floor.

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16. UNISTRUT HANGERS:

16.1. Unistrut hangers shall be used to support cable trays and shall be suspended from ceiling of vault. Each unistrut hanger shall be capable of supporting 500 lbs. Unistruts will be spaced such that the maximum load at each unistrut hanger is no more than 250 lbs.

16.2. Sufficient unistrut hangers shall be installed such that not more than one cable tray splice plate connection is located between hangers. Curved sections shall have at least one unistrut hanger at the center of the curved section.

17. SDG&E WILL FURNISH AND INSTALL:

17.1. Transformers

17.1.1. _____Transformer(s), _____ kV. _____/_____ Volt Connected for Three-Phase 4-Wire Service (Weight_____lbs.)

17.1.2. _____Transformer(s), _____ kV. _____/_____ Volt Connected for Three-Phase 4-Wire Service (Weight_____lbs.)

17.1.3. _____Transformer(s), _____ kV. 120/240 Volt Connected for _1_-Phase __4__-Wire Service (Weight_____lbs.)

17.2. 12KV Distribution Cable and Connectors

17.2.1. **Distribution Equipment:** SDG&E will furnish and install in vault (a) cable taps, (b) transformers, (c)_____-way switch (_____lbs.), (d) wall-mounted fuse cabinet(s) and fuses, (e) capacitor (2,000 lbs.), (f) SCADA and communication equipment.

17.2.1.1. Equipment Dimensions

17.2.1.1.1. Cable Taps

17.2.1.1.2. Transformers

17.2.1.1.3. Switches

17.2.1.1.4. Fuse Cabinets

17.2.1.1.5. Capacitors

17.2.1.1.6. SCADA and Communication Equipment

17.2.2. **Service Conductors:** SDG&E will furnish and install service entrance conductors from transformer secondary terminals to customer's service pull section only when criteria in Section 10.1 (above) are satisfied. Otherwise, customer will install bus duct.

NOTE: CUSTOMER SERVICE ENTRANCE DESIGN AND LOCATION TO BE APPROVED BY SDG&E PRIOR TO FABRICATION.

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18. BUS DUCT INTO PADMOUNTED TRANSFORMER:

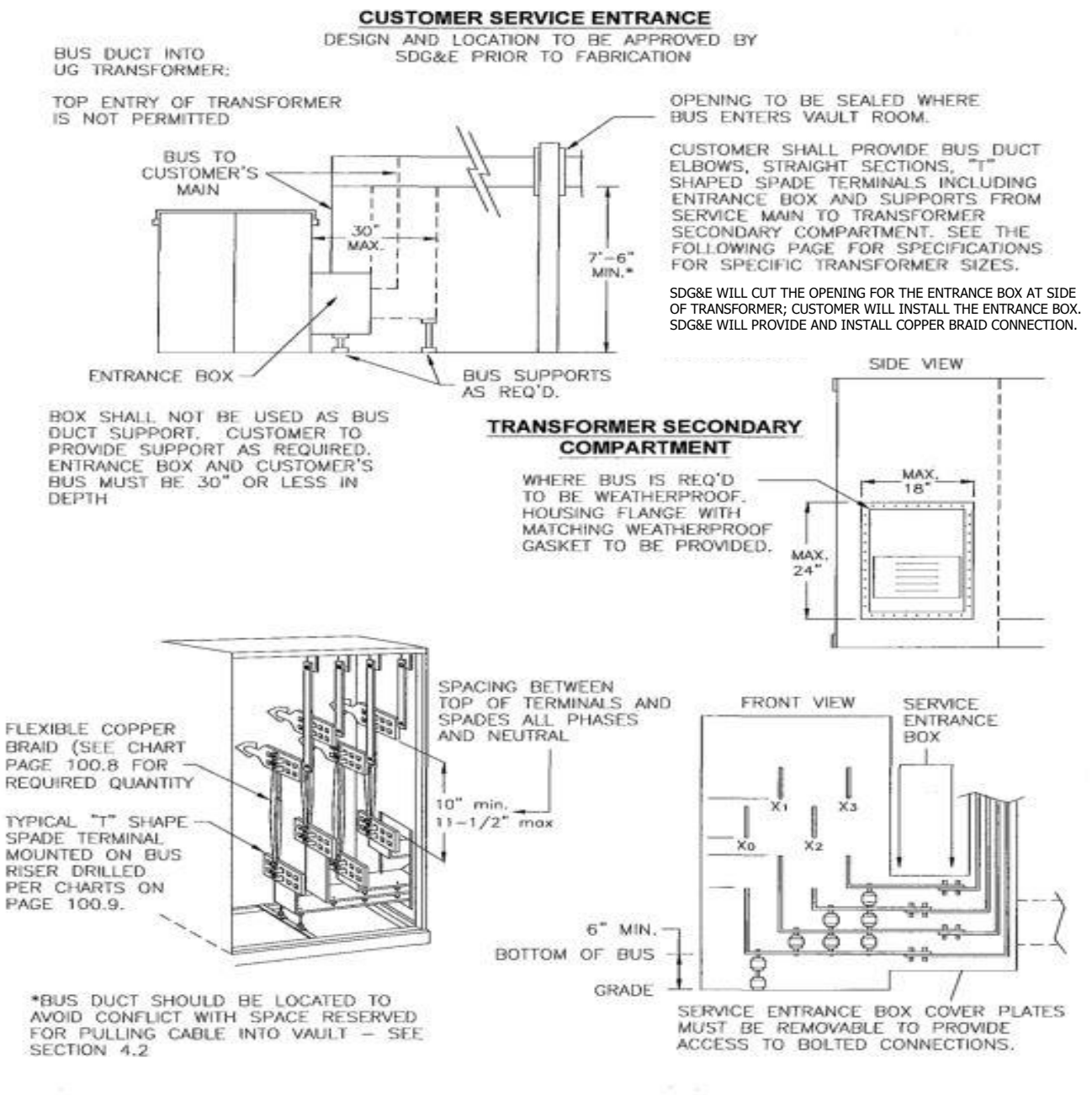


Figure 2: Typical Bus Duct Configuration for Padmounted Transformer

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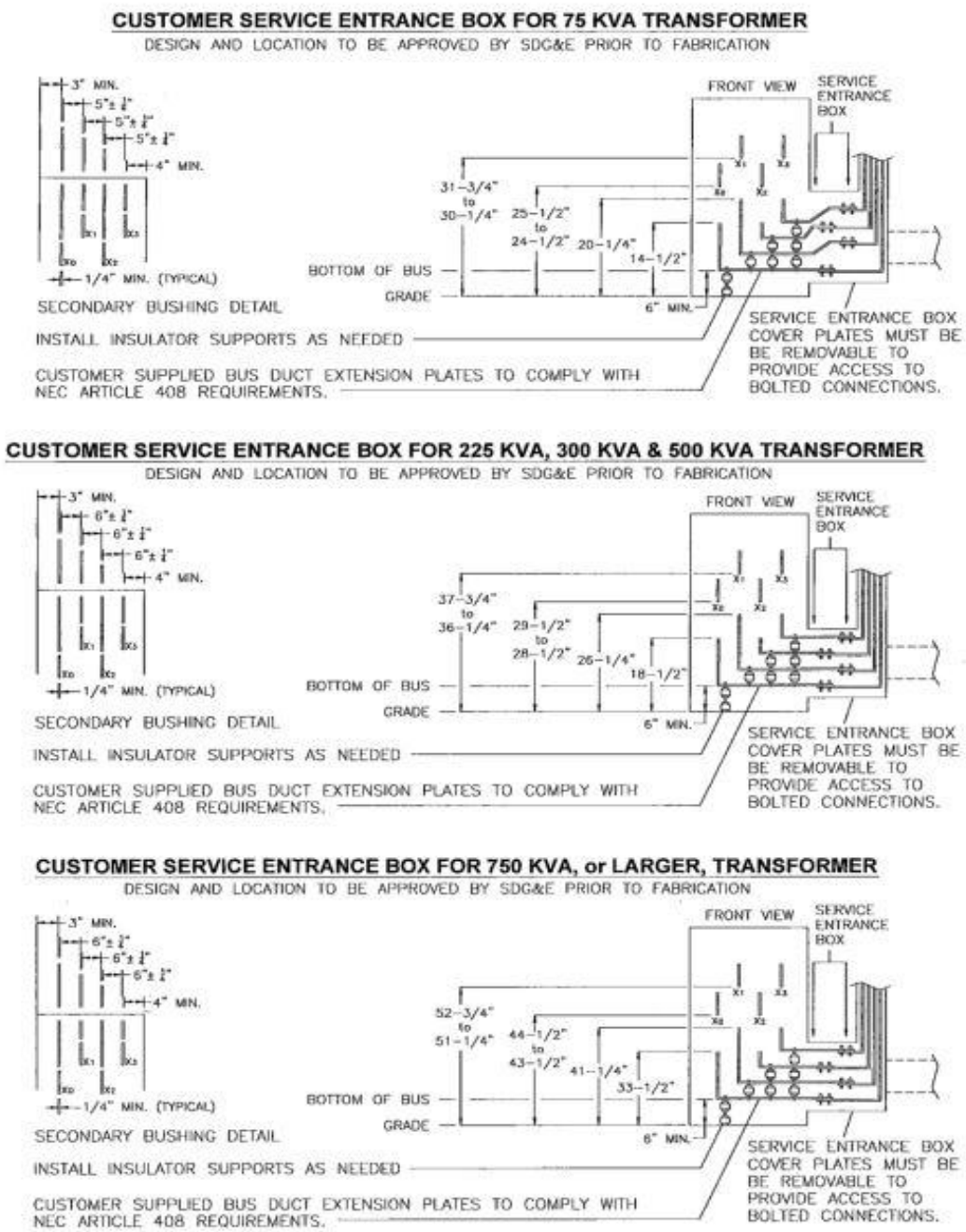


Figure 3: Typical Service Entrance Configuration for Various Sizes of Transformers

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19. COPPER BRAID SIZING CHART:

19.1. Three-phase padmount transformers (number of 600A secondary braided jumpers per phase to be used).

Secondary Voltage			
KVA	**208Y/120**	**240 DELTA**	**480Y/277**
75	1	1	1
150	1	1	1
225	2	2	1
300	2	2	1
500	4	3	2
750	6	—	3
1000	7	—	3
1500	11	—	5
2000	—	—	6
2500	—	—	8
3000	—	—	9

Table 1: Number of 600A Secondary Braided Jumpers Based on Transformer kVA Size and Secondary Voltage

20. LOW VOLTAGE TERMINALS:

Low Voltage Terminals				
KVA X-6 Holes	**KVA X-6 Holes**	**KVA X-6 Holes**	**KVA X-6 Holes**	**Voltage**
-	500	750	1000	208Y/120
750	1000	1500	2000 - 3000	480Y/277

Table 2: Number of "T" Spade Terminal Holes Based on Transformer kVA Size and Secondary Terminal Voltages

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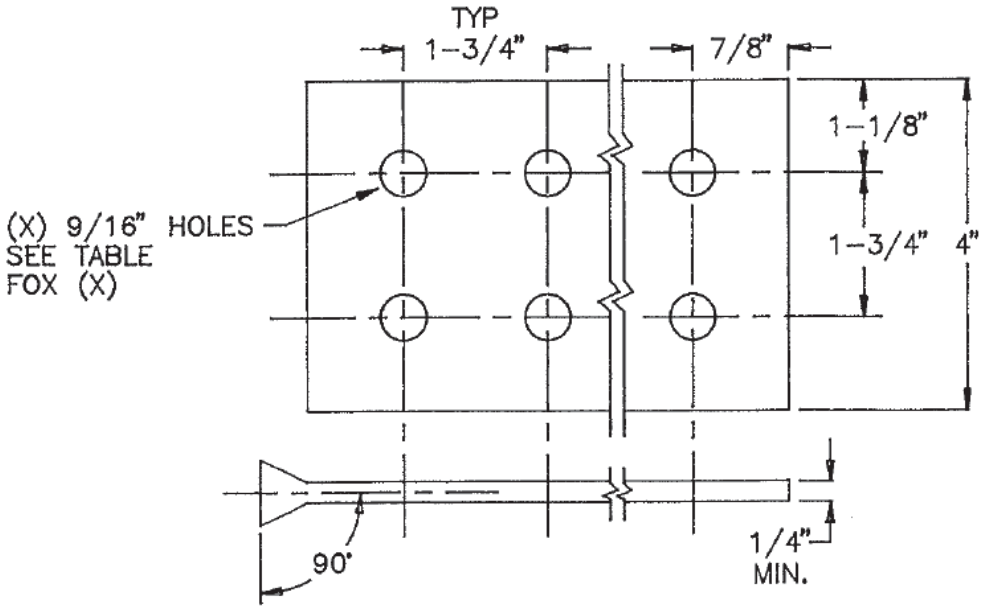


Figure 4: "T" Spade Termina Dimensions

A MIN.	KVA	B MIN.	E
5±1/4"	75	6±1/4"	27±1/2"
5±1/4"	150	6±1/4"	27±1/2"
6±1/4"	225	8±1/4"	31±1/2"
6±1/4"	300	8±1/4"	31±1/2"
6±1/4"	500	8±1/4"	31±1/2"
6±1/4"	750	8±1/4"	46±1/2"
6±1/4"	1000 -3000	8±1/4"	46±1/2"

Table 3: Secondary Bushing Spatial Dimensions

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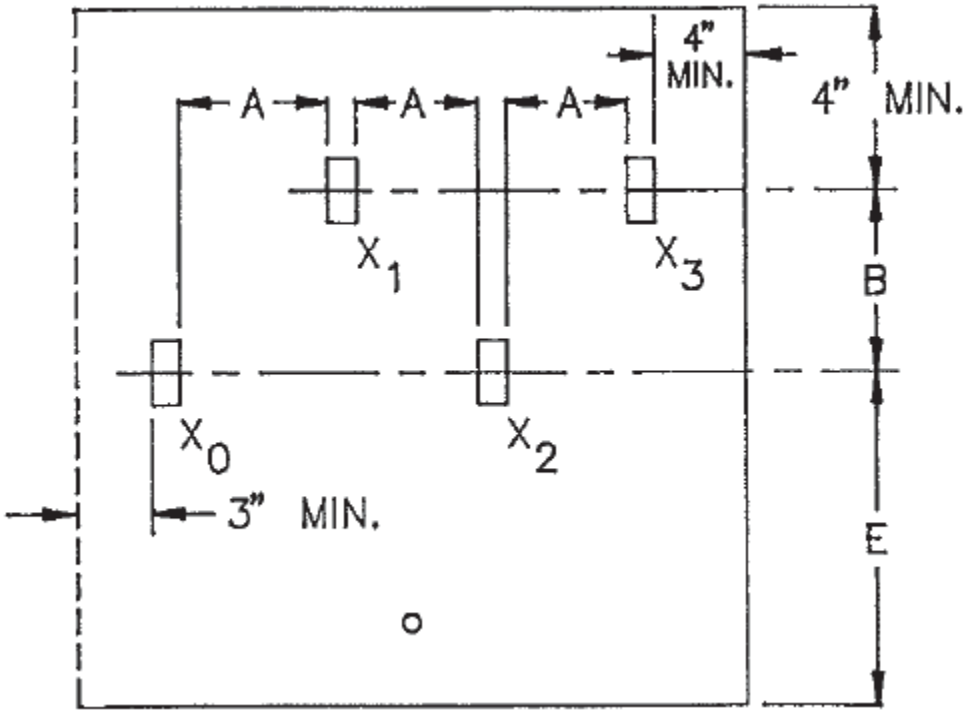


Figure 5: Secondary Bushing Spatial Diagram

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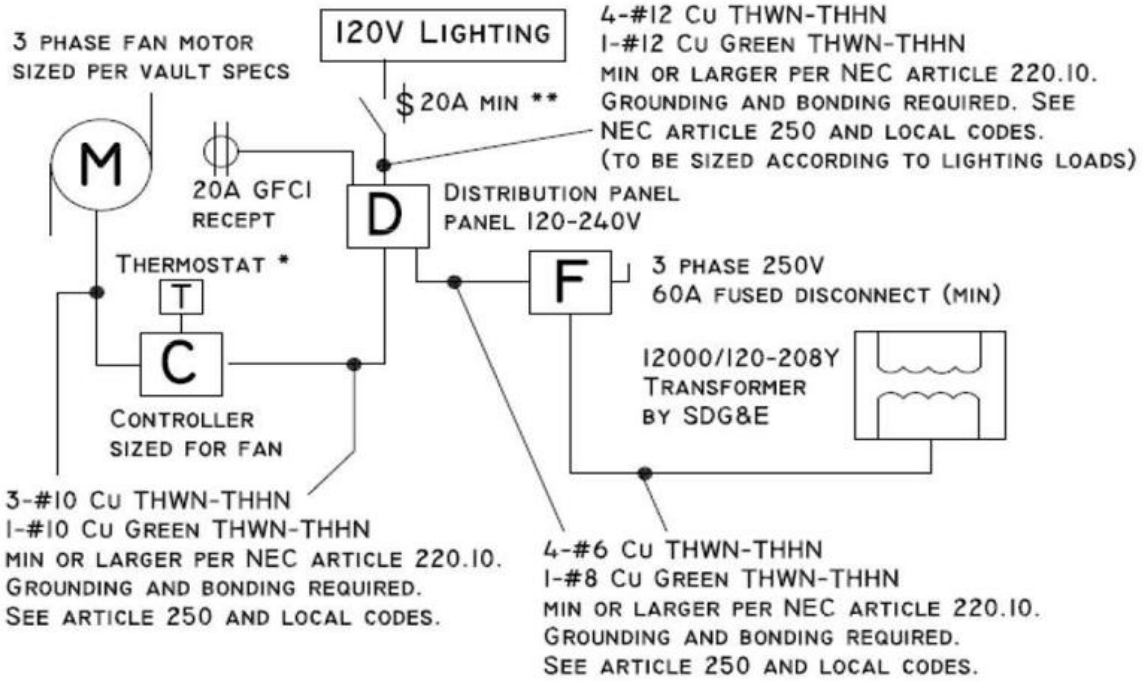
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21. INTERNAL VAULT WIRING:

21.1. 120 – 208V Vault (Alternate, only use if 277 – 480V not present):



120-208V Vault

* THERMOSTAT TO BE MOUNTED AWAY FROM INTAKE AND EXHAUST VENTS IN ANY EASILY ACCESSILBLE LOCATION.

** LIGHT SWITCH WITH LIGHTED SWITCH PLATE REQUIRED INSIDE VAULT (A) ADJACENT TO PERSONNEL ACCESS DOOR AND (B) BELOW 34" CAST IRON COVER/PERSONNEL ACCESS OPENING, 48" ABOVE THE FLOOR.

NOTE: ANY MODIFICATIONS OR ADDITIONS TO THESE SPECIFICATIONS SHALL COMPLY WITH ALL APPLICABLE NEC AND LOCAL CODES.

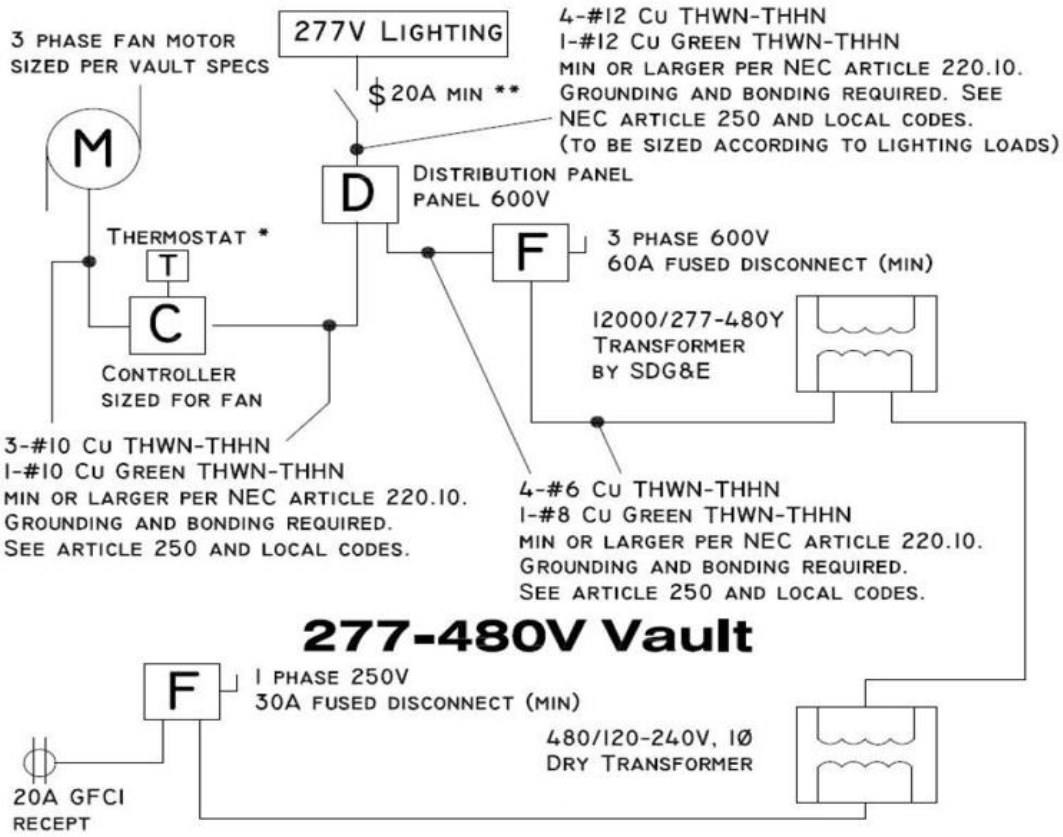
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A	ORIGINAL ISSUE	-	-	-	-	11/20/2018	D	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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21.2. 277 – 480V Vault (Preferred):



120V Vault Power from 277-480 Y Transformer

* THERMOSTAT TO BE MOUNTED AWAY FROM INTAKE AND EXHAUST VENTS IN ANY EASILY ACCESSILBLE LOCATION.

** LIGHT SWITCH WITH LIGHTED SWITCH PLATE REQUIRED INSIDE VAULT (A) ADJACENT TO PERSONNEL ACCESS DOOR AND (B) BELOW 34" CAST IRON COVER/PERSONNEL ACCESS OPENING, 48" ABOVE THE FLOOR.

NOTE: ANY MODIFICATIONS OR ADDITIONS TO THESE SPECIFICATIONS SHALL COMPLY WITH ALL APPLICABLE NEC AND LOCAL CODES.

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22. EQUIPMENT OPENINGS IN VAULT WALL:

22.1. 8ft. X 10ft. Door required for equipment opening. May NOT be a roll-up door.

22.2. Either style door must be 3-hour fire rated. See Section 3.1 and 3.2.

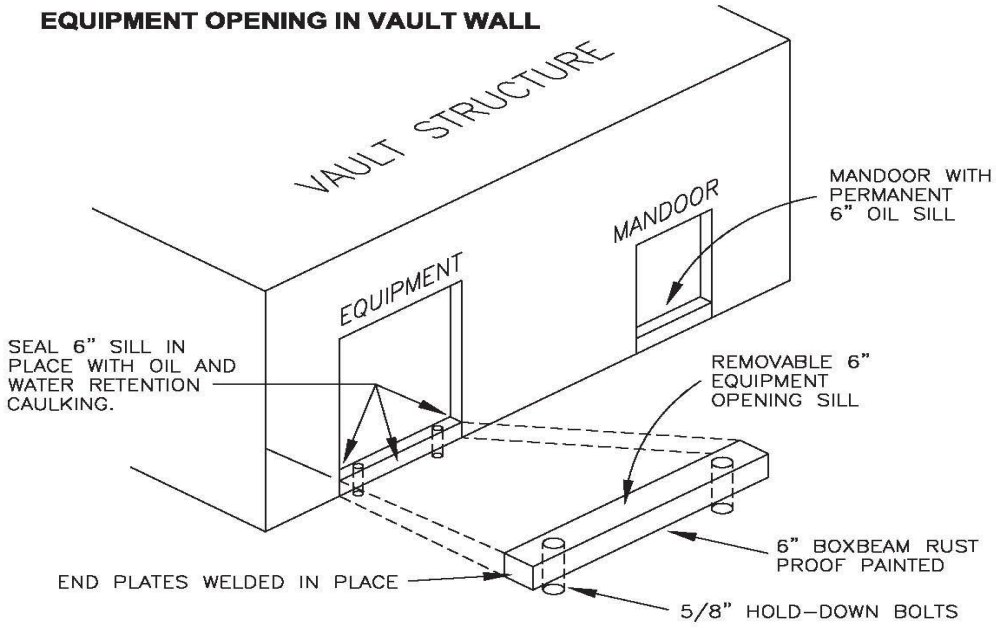


Figure 6: At Grade Vault Equipment and Personnel Access Door

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

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23. ELECTRIC VAULT LOCATION & ACCESSIBILITY:

23.1. At Grade Vault (Preferred):

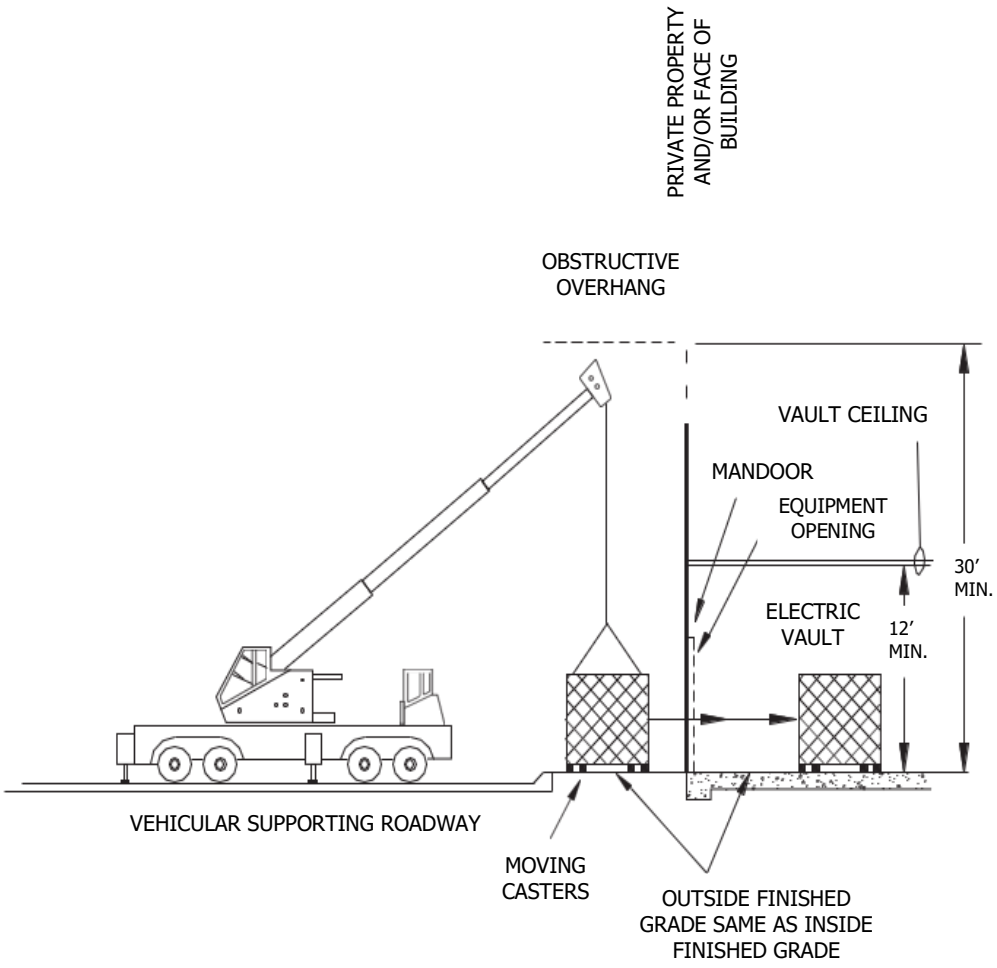


Figure 7A: Access to Equipment Openings for At Grade Vaults

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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	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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23.2. Below Grade Vault (Alternate)

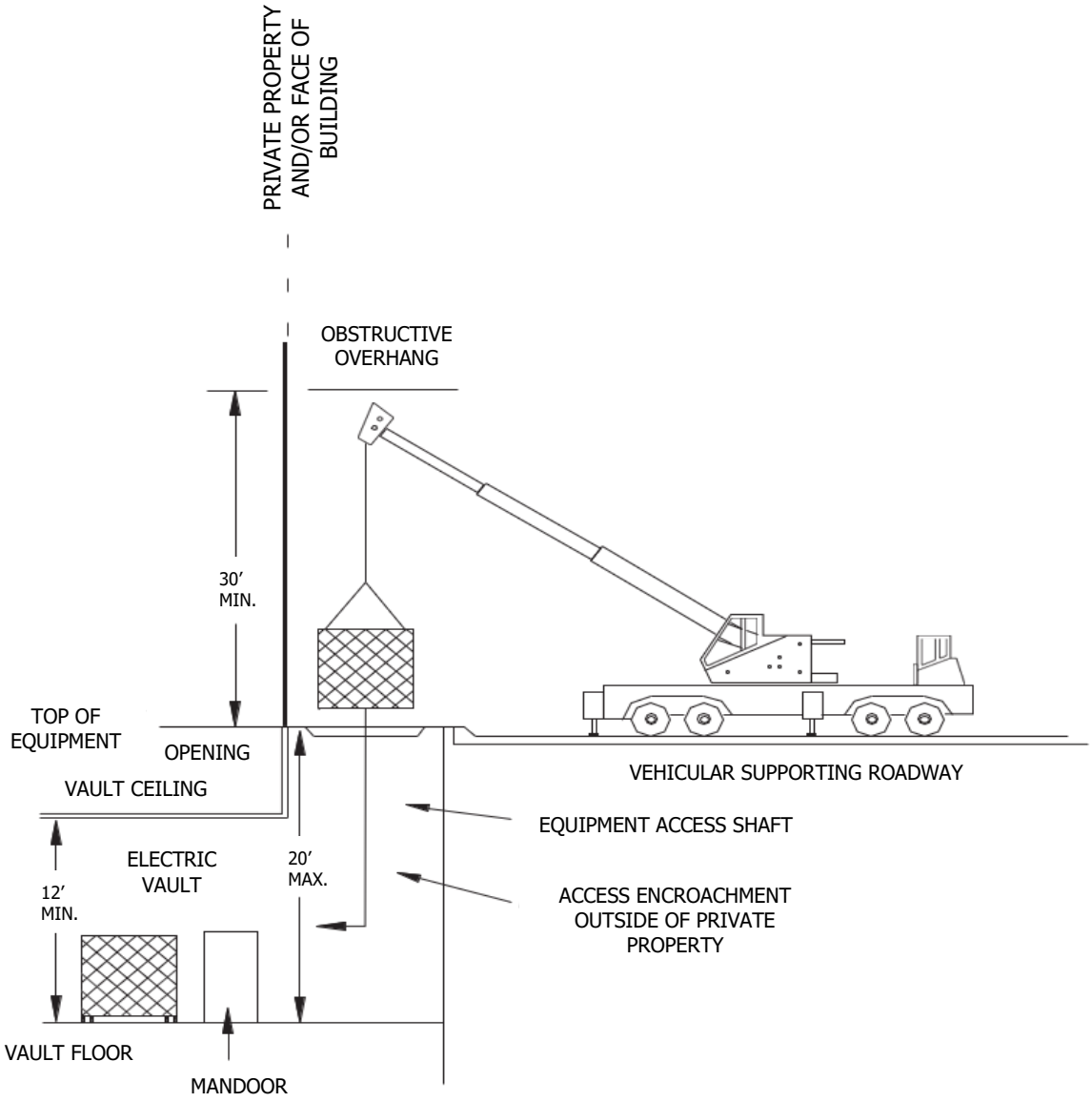


Figure 7B: Access to Equipment for Below Grade Vaults

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REV	CHANGE	DR	BY	DSN	APV	DATE	REV	CHANGE	DR	BY	DSN	APV	DATE
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	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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24. VAULT INTERNAL DIMENSIONS: BELOW GRADE & STREET LEVEL VAULTS:

Customer Type	Number of Transformers (26.1)		Clear and unobstructed space (26.1/.2 /.3 /.5)	Equipment opening & personnel access opening
	1Ø	3Ø		
Residential Only	1	1	18′ X 16′ (at grade)	(not required at grade)
	1	1	18′ X 16′ (below grade)	17′ X 12′ (min)
Commercial or Combination W/Residential	-	1	20′ X 44′ (26.4)	17′ X 12′ (min) (not required at grade)
	-	2	36½′ X 29′ or 20′ x 57′	17′ X 12′ (min) (not required at grade)
	-	3	20′ x 70′	17′ X 12′ (min) (not required at grade)

Table 4: Non-Custom Vault Dimensions Based on Type of Service and Equipment Needs

24.1. Customer must contact SDG&E Project Management Department to determine dimensions for transformer combinations not listed. Contact SDG&E prior to submitting architectural building plans for Municipal approval.

24.2. Customer desiring deviation from standard vault dimensions must make formal written requests to SDG&E Project Management Department for consideration. Requests must be submitted to SDG&E prior to submitting architectural building plans for municipal approval.

24.3. If customer is not able to provide clear & unobstructed space (no columns) in the dimensions specified above, please contact SDG&E Project Management Department to determine acceptable alternative to prescribed dimensions above. Customer must coordinate with SDG&E prior to submitting architectural building plans for Municipal approval.

24.4. Customer may use 36½ft. x 29ft. dimensions if convenient.

24.5. Customer may provide larger vault than minimum dimensions listed above.

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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	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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25. LADDER INSTALLATION FOR VAULTS GREATER THAN 12-FOOT (BELOW GRADE):

25.1. Minimum Vault Depth 12-foot, Maximum Vault Depth 20-foot.

25.2. Sump hole required, centered directly below personnel access opening.

25.3. SDG&E will supply ladder when needed.

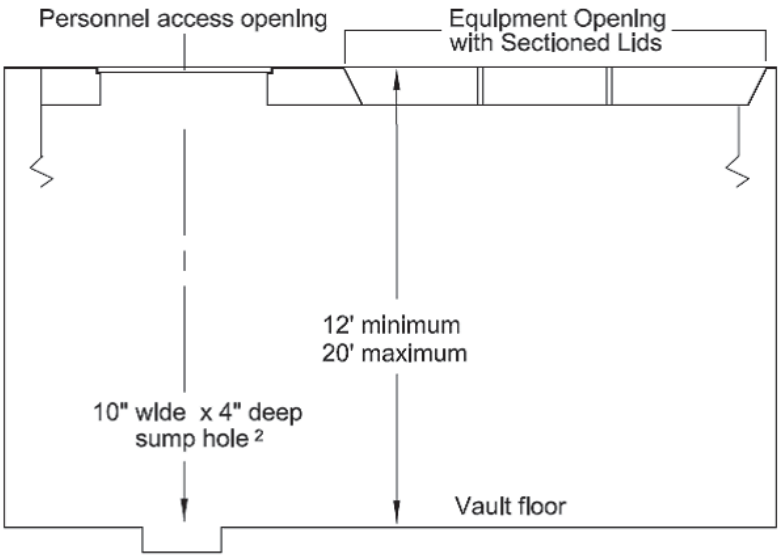


Figure 8: Side-View – Facing Street

26. VAULT EQUIPMENT COVER AND PERSONNEL ACCESS OPENING (BELOW GRADE):

26.1. Inside dimension of equipment opening shall measure 10ft. x 10ft. Customer shall provide removable three-hour fire rated three-part concrete equipment opening covers. No coverings or facades are permitted over these covers unless an integral part of the covers themselves. Maximum weight of each section is not to exceed 4,800 lbs.

26.2. Customer to provide 4 lifting inserts with removable plugs (to keep out debris) near each corner of each equipment opening cover/section. Lifting inserts shall be 1-inch threaded coil inserts with 4,500 lbs. safe working load tension – see Section 3 & 4.

26.3. Personnel access opening (manhole) shall measure 30-inch in diameter with 34-inch diameter cast iron cover and recessed stainless steel penta-head bolts (4 total). See SDG&E Underground Construction Standards 3332. Personnel access opening to be at final grade. No coverings are permitted over this opening.

26.4. Customer to submit plans approved by a civil engineer registered in the State of California verifying the structural integrity of equipment opening covers and personnel access opening cover to withstand (AASHTO) HS-20 loading. Equipment opening cover shall be designed in accordance with SDG&E Underground Construction Standards. Plans to be submitted to SDG&E prior to construction/manufacture of vault roof and sectioned equipment opening.

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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	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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26.5. Café fences, railings, partitions, enclosures, screens, barriers, walls, tables, chairs, umbrellas, podiums, or any other miscellaneous structures or furniture are not permitted above equipment opening cover or personnel access opening cover, temporarily or otherwise. 24-hour access for emergency and/or routine removal of covers is to be always maintained.

26.6. Equipment opening covers and personnel access open cover to sit flush with and at same grade as surrounding sidewalk.

26.7. Customer shall install felt insulation between concrete equipment opening covers and metal side rails/struts - to prevent surface vacuum buildup between covers and side rails. Install felt insulation such that top horizontal surface of insulation is 1/2-inch – 1-inch below top surface of covers. Customer to seal perimeter of equipment opening covers with removable ultraviolet/water/oil resistant caulking.

26.8. Equipment Opening & Personnel Access Opening shall be no more than 2-foot from edge of curb*.

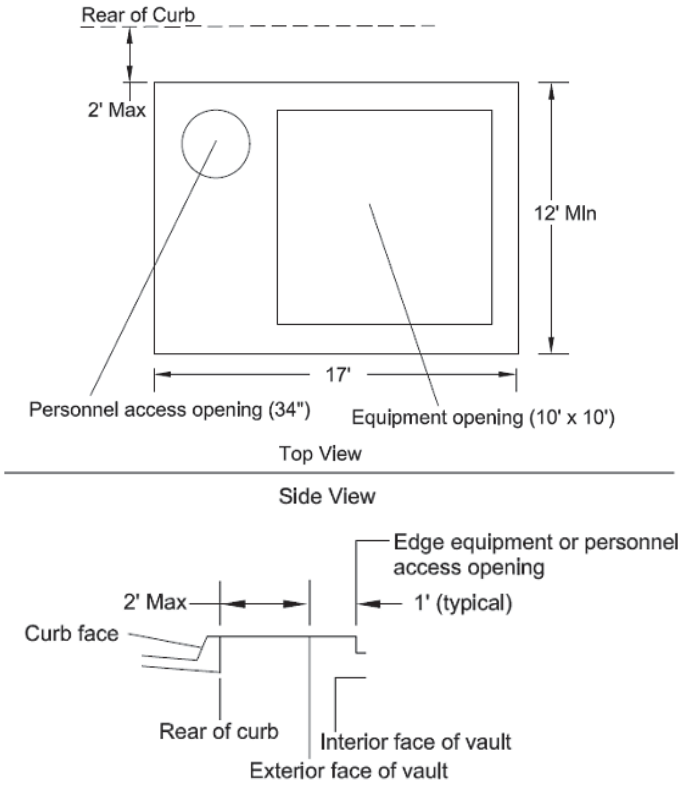


Figure 9: Proximity of Below Grade Vault Equipment and Personnel Access Opening to Street

***NOTE:** Customer is not permitted to install tables, chairs, partitions, posts, signs, screens, walls, fences, railings or barriers of any nature above or in front of SDG&E equipment opening or personnel access opening.

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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	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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26.9. The following depiction shows typical arrangements of the "Clear & Unobstructed Space" (vault space for equipment) to the "Equipment and Personnel Access Opening".

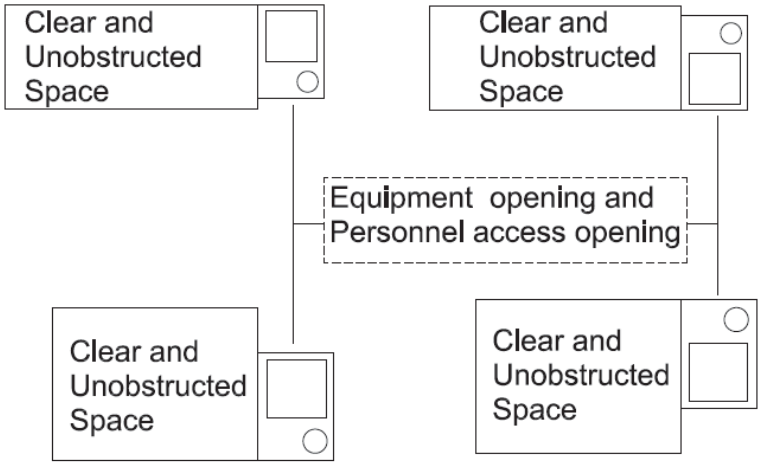


Figure 10: Typical Arrangement of Vault Room in Relation to Equipment and Personnel Access Opening

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27. TYPICAL VAULT CONFIGURATIONS (AT & BELOW GRADE):

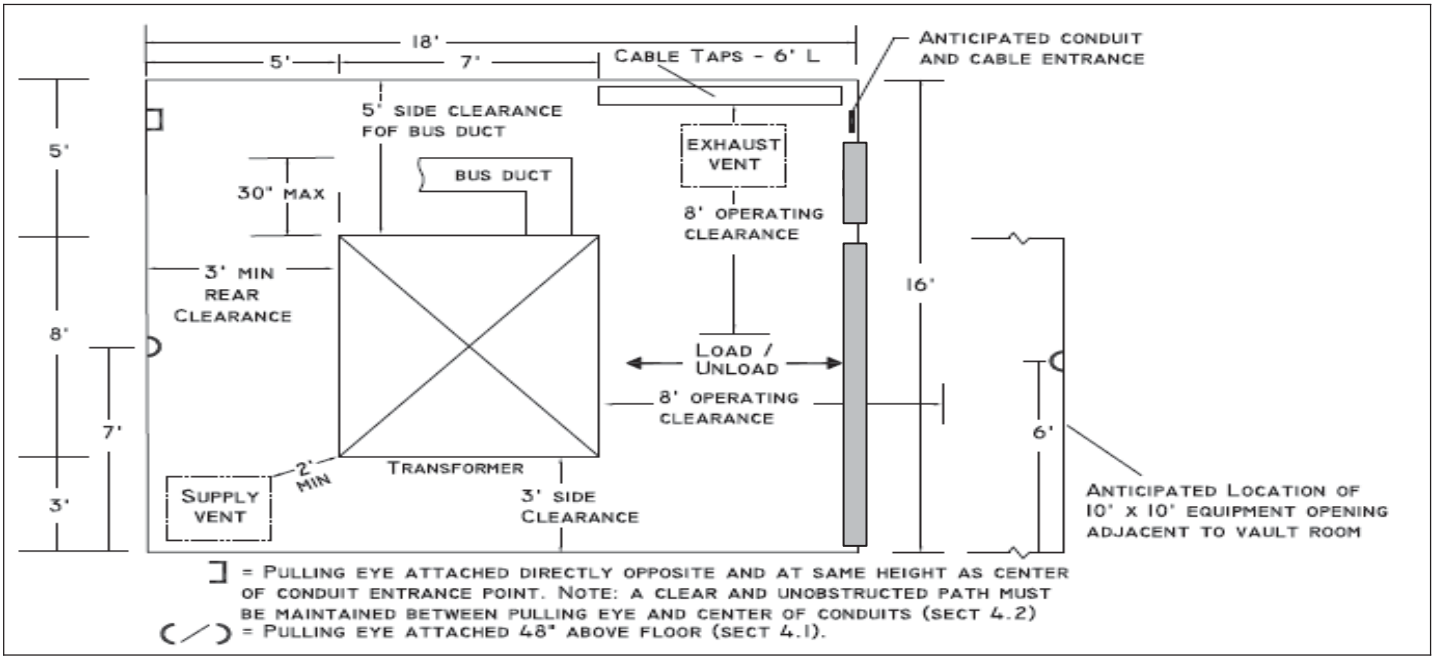


Figure 11: Typical Below Grade Residential Vault Configuration for One Transformer

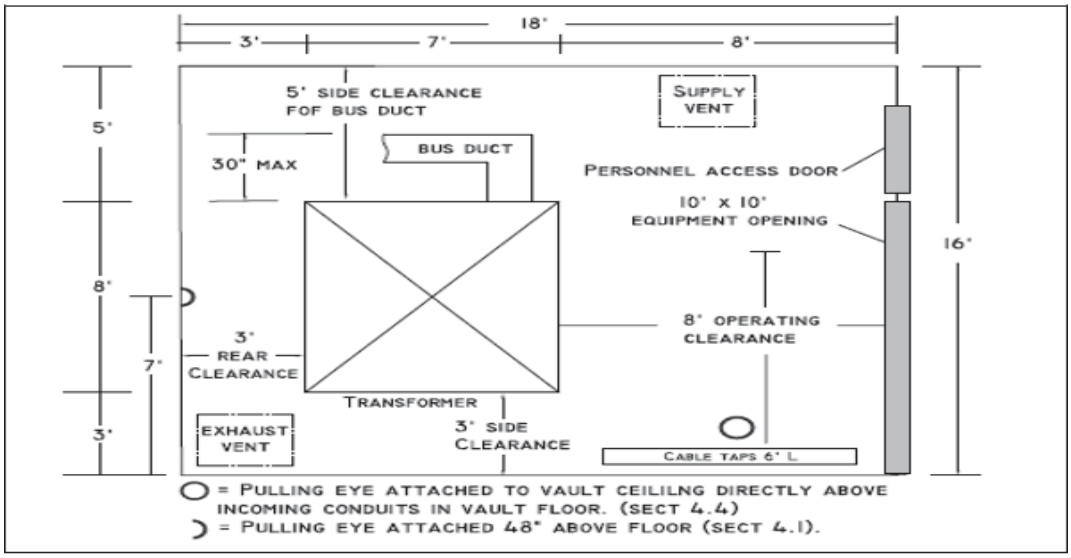


Figure 12: Typical at Grade Residential Vault Configuration for One Transformer

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B	EDITORIAL CHANGES	YZZ	JES	FRC	JJP	10/31/2025	E						
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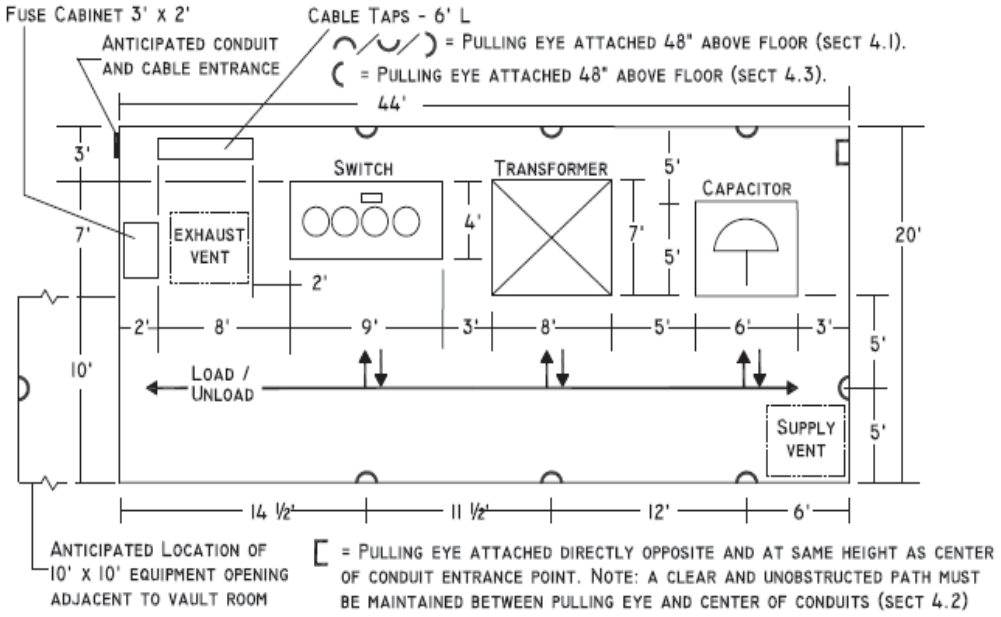


Figure 13: Typical Below Grade Commercial Vault Configuration for One Transformer

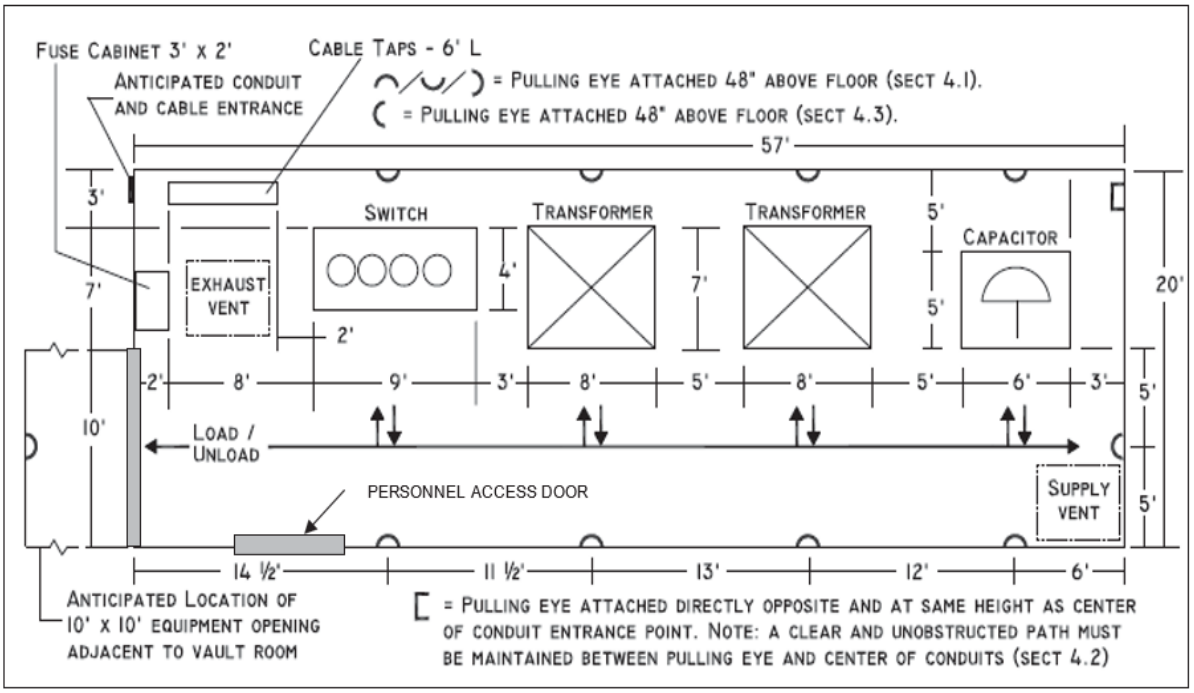


Figure 14: Typical Below Grade Commercial Vault Configuration for Two Transformers

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B	EDITORIAL CHANGES	YZZ	JES	FRC	JJP	10/31/2025	E						
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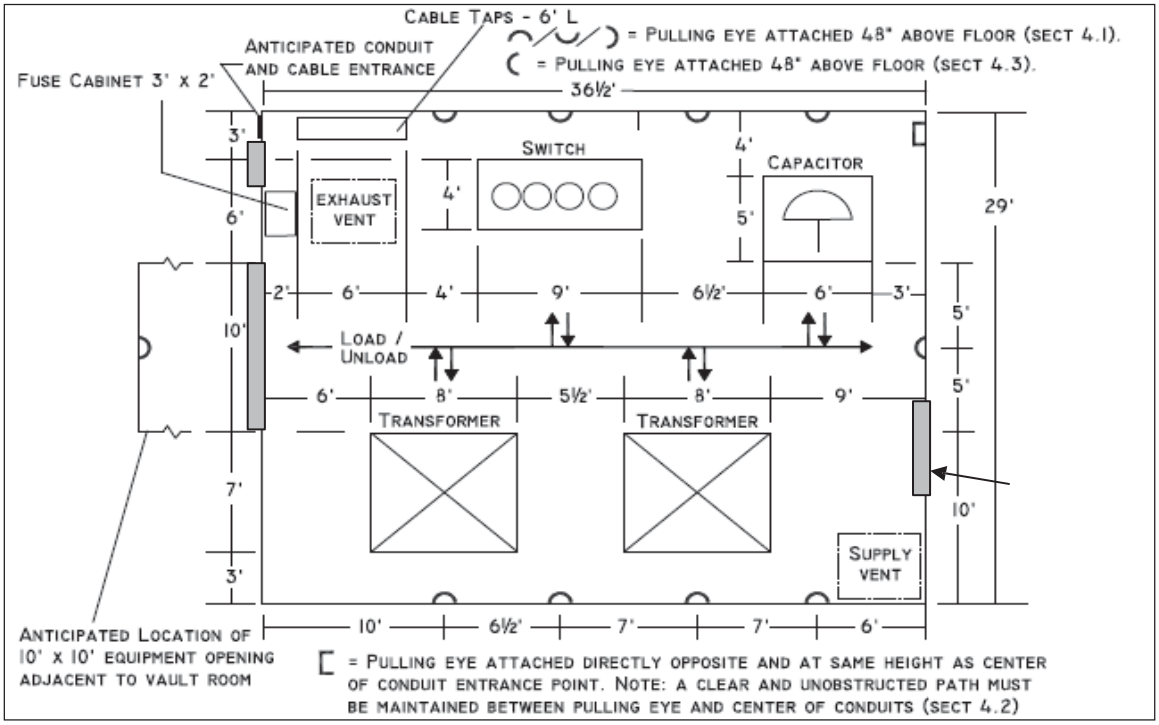


Figure 15: Typical (Square) Below Grade Commercial Vault Configuration for Two Transformers

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A	ORIGINAL ISSUE	-	-	-	-	11/20/2018	D	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

28. CONSTRUCTION & MAINTENANCE RESPONSIBILITIES:

The customer/owner shall furnish, construct and own the transformer vault facilities as specified. The customer/owner will be responsible for the maintenance of the vault facilities installed for the duration of service. This includes any part of the vault structure extending into the public right-of-way, or outside of the project boundary.

The customer, owner or authorized representative agrees to provide, construct and maintain permanent truck & equipment access, and boom clearance for SDG&E's use at any equipment access opening located within the customer /owner's land. See Sections 3.3 - 3.8 for specific requirements. Customer, owner or authorized representative also agrees to position equipment access opening that is adjacent to public right-of-way or in public right-of-way such that it provides the same access as when located within customer/owner's land. Access route shall be capable of supporting truck weight class H20 (20 tons per axel).

SDG&E will be represented in the field by an inspector and all work, and material shall always be subject to inspection. Our inspector may be contacted prior to the start of your construction to answer any question you may have concerning your project. Final acceptance by SDG&E will be made when you have completed all work to the satisfaction of our inspector. The meters can only be set after final acceptance of your work, completion of our work, application for service, and receipt of final building inspection clearance.

All materials, work and work areas shall comply with the CAL-OSHA, Federal OSHA, and all other applicable federal, state, or local safety laws or rules that are necessary to protect applicant's and utility's employees, the public, and workers during the time of construction.

By proceeding with this installation, it is understood that you agree to all the stipulations set forth in these specifications and drawings indicated herein.

Customer / Owner _____Date_____

Customer (Print Name) _____

Authorized Customer Representative _____Date_____

Authorized Customer Representative (Print Name) _____

SDG&E Representative _____Date_____

SDGE&E Representative (Print Name) _____

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B	EDITORIAL CHANGES	YZZ	JES	FRC	JJP	10/31/2025	E						
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SCOPE: This design standard describes the below grade single transformer vault requirements for 120/208V and 277/480V.

ATTENTION:

* This document provides historical design guidelines along with current design information necessary for vault design. This document is for design use only and not to be provided to the customer.

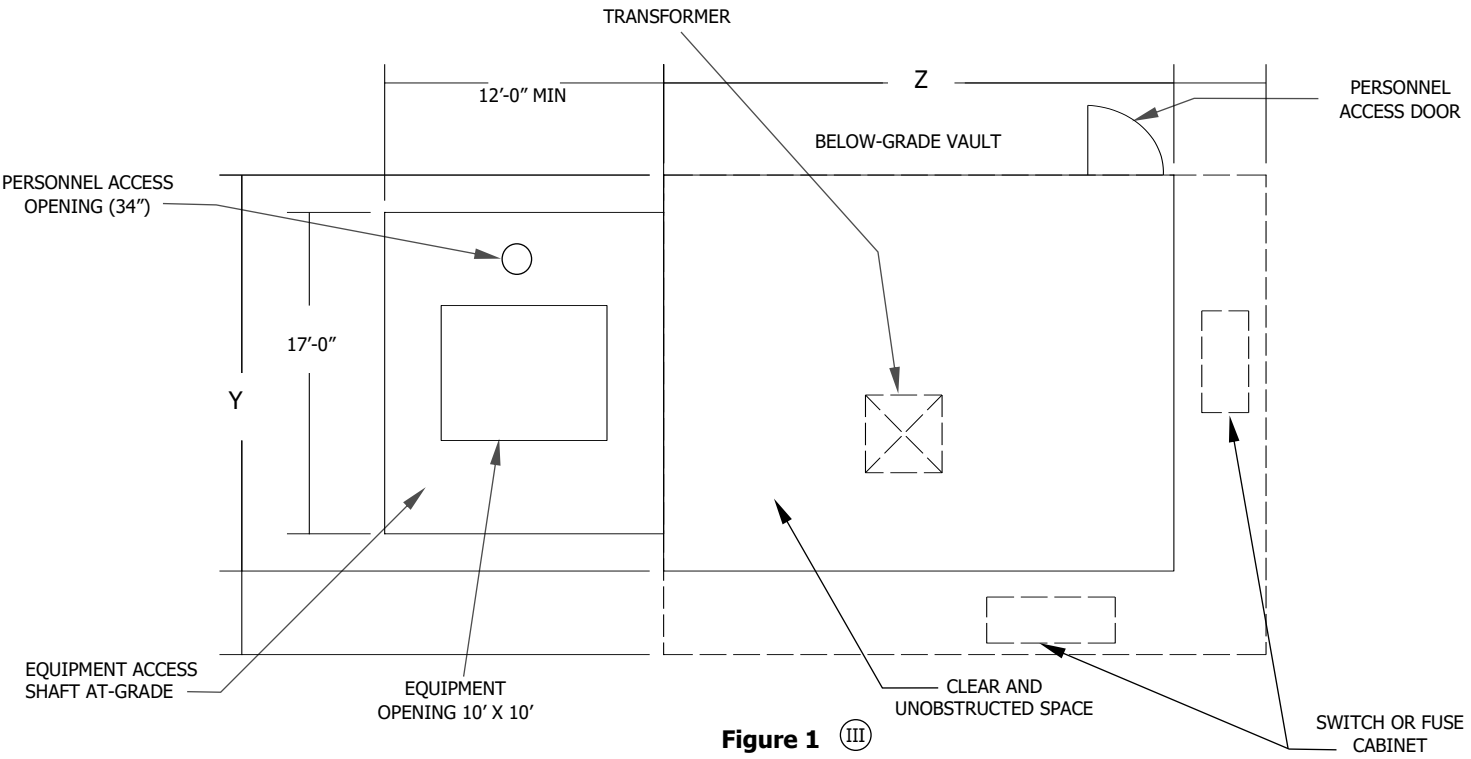


Figure 1 (III)

TABLE 1: BELOW GRADE
MINIMUM ELECTRIC VAULT REQUIREMENTS FOR
SINGLE TRANSFORMER INSTALLATION – 3-PHASE TRANSFORMER

CUST. BOARD SIZE	208V TRANSF. SIZE (KVA)	480V TRANSF. SIZE (KVA)	FRONT TO BACK LENGTH Z (IV)	WALL TO WALL WIDTH Y	ALONG W/TRANSF. SWITCH INST. ON SIDE WALL		ALONG W/TRANSF. SWITCH INST. ON END WALL		FLOOR TO CEILING HEIGHT	CEILING EQUIPMENT OPENING	TRANSF. WEIGHT LBS	SUMP CAP. GALLONS
					LENGTH Z	WIDTH Y	LENGTH Z	WIDTH Y				
120/208V												
200	75	--	13'-6"	12'-0"	NA				12' Min – 20' Max	10'-0" X 10'-0"	3,500	240
400	150	--	13'-6"	12'-0"					12' Min – 20' Max		3,900	240
600	225	--	14'-0"	12'-0"					12' Min – 20' Max		4,200	240
800	300	--	15'-0"	12'-0"					12' Min – 20' Max		5,000	255
1000	300	--	15'-0"	12'-0"					12' Min – 20' Max		5,000	255
1200	500	--	16'-6"	12'-6"	21'-6"	15'-0"	19'-6"	20'-9" (IV)	12' Min – 20' Max		6,600	290
1600	500	--	16'-6"	12'-6"	21'-6"	15'-0"	19'-6"	20'-0" (IV)	12' Min – 20' Max		6,600	290

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B	EDITORIAL CHANGES	EDM	ADW	JES	KRG	04/22/2022	E						
A	ORIGINAL ISSUE	-	-	-	-	06/22/2004	D	EDITORIAL CHANGES	YZZ	FRC	FRC	FRC	07/22/2026

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TABLE 1 (CONT'D):

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MINIMUM ELECTRIC VAULT REQUIREMENTS FOR
SINGLE TRANSFORMER INSTALLATION – 3-PHASE TRANSFORMER

CUST. BOARD SIZE	208V TRANSF. SIZE (KVA)	480V TRANSF. SIZE (KVA)	FRONT TO BACK LENGTH Z (IV)	WALL TO WALL WIDTH Y	ALONG W/TRANSF. SWITCH INST. ON SIDE WALL		ALONG W/TRANSF. SWITCH INST. ON END WALL		FLOOR TO CEILING HEIGHT	CEILING EQUIPMENT OPENING	TRANSF.WEIGHT LBS	SUMP CAP. GALLONS
					LENGTH Z	WIDTH Y	LENGTH Z	WIDTH Y				
120/208V												
2000	750	--	17′ 0″	12′-6″	22′-6″	15′-0″	20′-0″	20′ -0″ (IV)	12′ Min – 20′ Max	10′-0″ X 10′-0″	7,550	425
2500	1000	--	18′ 0″	13′-6″	23′-6″	16′-6″	21′-6″	20′ -0″ (IV)	12′ Min – 20′ Max		8,200	435
3000	1000	--	18 -0″	13′-6″	23′-0″	16′-6″	21′-6″	20′ -0″ (IV)	12′ Min – 20′ Max		8,200	435
4000	1000 1500	--	20′-0″	16′-0″	25′-6″	19′-0″	23′-0″	20′ -0″ (IV)	12′ Min – 20′ Max		10,150	515
277/480V												
200	--	150	13′-6″	9′-6″	NA				12′ Min – 20′ Max	10′-0″ X 10′-0″	3,900	240
400	--	300	15′-0″	10′-6″					12′ Min – 20′ Max		5,000	255
600	--	500	16′-6″	12′-6″	21′-6″	15′-0″	19′-6″ (IV)	20′-0″	12′ Min – 20′ Max		6,600	290
800	--	500	16′-6″	12′-6″	21′-6″	15′-0″	19′-6″ (IV)	20′-0″	12′ Min – 20′ Max		6,600	290
1000	--	750	17′-0″	12′-6″	22′-6″	15′ 0″	20′-0″ (IV)	20′-0″	12′ Min – 20′ Max		7,550	425
1200	--	1000	18′-0″	13′-6″	23′-6″	16′-6″	21′-6″ (IV)	20′-0″	12′ Min – 20′ Max		8,200	435
1600	--	1000	18′-0″	13′-6″	23′-6″	16′-6″	21′-6″ (IV)	20′-0″	12′ Min – 20′ Max		8,200	435
2000	--	1500	20′-0″	16′-0″	25′-6″	19′ 0″	23′-0″ (IV)	20′-0″	12′ Min – 20′ Max		10,150	515
2500	--	2000	20′-0″	16′-6″	25′-6″	19′-6″	23′-0″ (IV)	20′-0″	12′ Min – 20′ Max		17,300	570
3000	--	2000	20′-0″	16′-6″	25′-6″	19′ 6″	23′-0″ (IV)	20′-0″	12′ Min – 20′ Max		17,300	570
4000	--	2500 3000 (V)	20′-0″	16′-6″	25′-6″	19′-6″	23′-0″ (IV)	20′-0″	12′ Min – 20′ Max		17,300	580

INSTALLATION: NONE

BILL OF MATERIALS: NONE

NOTES:

I. The dimensions in table 1 cover necessary work areas including fusing equipment mounted on wall within the 8ft work area in front of transformer.

II. Vaults all require standard 3′-0″ x 6′-8″ personnel access door adjacent to work area in front of transformer.

(III) Below-Grade vaults where personnel access door does not provide 24 hours access requires a 34″ diameter manhole access thru the At-Grade equipment access shaft. At-Grade equipment access shaft shall not access work area over equipment. (VI)

(IV) This dimension may be reduced by 2ft where personnel access door entrance is located just to the front and side of switch.

(V) Maximum allowed. (a)

(VI) At-Grade equipment access shaft for Below-Grade vaults, see Figure 2.

VII. For existing or legacy vault tables, see FMO DM5745.

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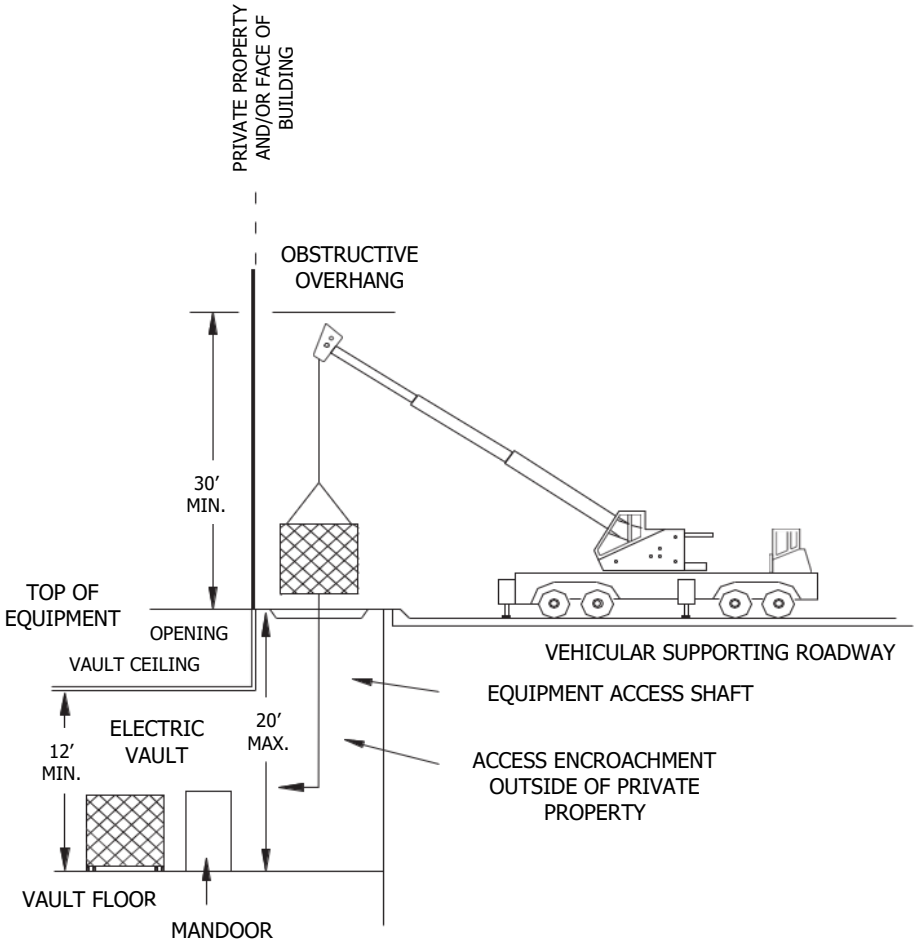


Figure 2

REFERENCE:

(a) See SDG&E Rule II. Description of Service

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SCOPE: This design standard describes the below grade multiple transformer vault requirements for 120/208V and 277/480V.

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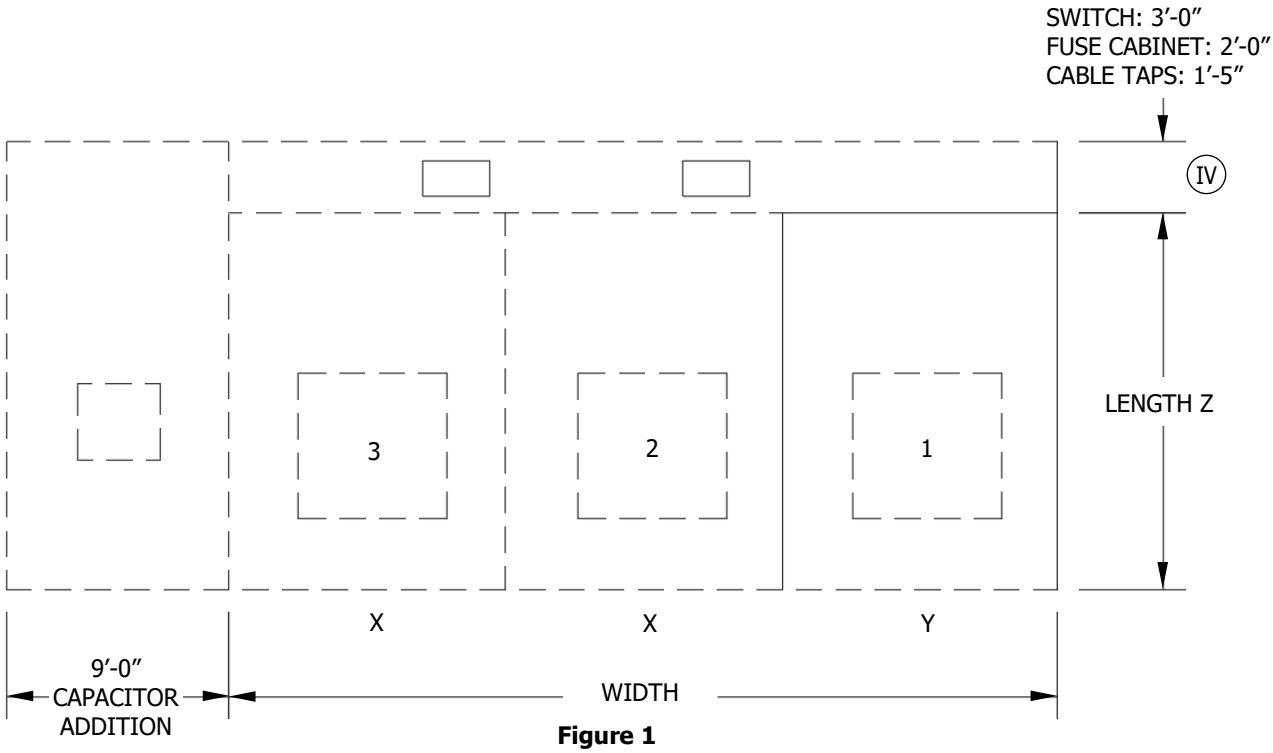


Figure 1

TABLE 1: BELOW GRADE MULTIPLE TRANSFORMER INSTALLATION (III)
MINIMUM VAULT DIMENSIONS FOR MULTI-SERVICES

120/208V SIDE BY SIDE	**MINIMUM VAULT DIMENSIONS FOR ONE SERVICE PANEL**										
	MAIN SIZE	**200i**	**400i**	**600i**	**800i**	**1000i**	**1200i**	**1600i**	**2000i**	**2500i**	**3000i**	**4000i**
	LENGTH Z	13'-6"	13'-6"	14'-0"	15'-0"	15'-0"	16'-6"	16'-6"	17'-0"	18'-0"	18'-0"	20'-0"
	WIDTH Y	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	13'-6"	16'-0"
	ADDITIONAL VAULT WIDTH FOR EACH ADDED SERVICE MAIN											
	WIDTH X	7'-6"	7'-6"	7'-6"	8'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"
277/480V SIDE BY SIDE	**MINIMUM VAULT DIMENSIONS FOR ONE SERVICE PANEL**											
	MAIN SIZE	**200i**	**400i**	**600i**	**800i**	**1000i**	**1200i**	**1600i**	**2000i**	**2500i**	**3000i**	**4000i**
	LENGTH Z	13'-6"	15'-0"	16'-6"	16'-6"	17'-0"	18'-0"	18'-0"	20'-0"	20'-0"	20'-0"	20'-0"
	WIDTH Y	9'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	16'-0"	16'-6"	16'-6"	16'-6"	16'-6"
	ADDITIONAL VAULT WIDTH FOR EACH ADDED SERVICE MAIN											
	WIDTH X	7'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"	12'-6"	12'-6"	12'-6"

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INSTALLATION: NONE

BILL OF MATERIALS: NONE

NOTES:

I. To calculate multiple service vault dimension, start with largest applicable main size, then add appropriate footages for each additional service main.

II. **Example:**

120/208V

Customer's 1-3000i AND 1-2000i

	Z	**Y**
3000i =	18'-0"	13'-6"
2000i =	--	9'-6"
switch, fuse cabinet and cable Taps =	3'-0"	--
Cap. =	--	9'-0"
Vault Dim's. =	21'-0"	32'-0"

III Dimensions are typical and may vary depending on customer's actual allocated space for vault. Rearranging facilities with necessary requirements to be worked out with project engineer. The following vault dimensions may also be used to facilitate plan review:

VAULT INTERNAL DIMENSIONS: BELOW GRADE & STREET LEVEL VAULTS

Customer Type	Number of Transformers (26.1)		Clear and unobstructed space (26.1/.2 /.3 /.5)	Equipment opening & personnel access opening
	1Ø	3Ø		
Residential Only	1	1	18' X 16' (at grade)	(not required at grade)
	1	1	18' X 16' (below grade)	17' X 12' (min)
Commercial or Combination W/Residential	-	1	20' X 44' (26.4)	17' X 12' (min) (not required at grade)
	-	2	36½' X 29' or 20' x 57'	17' X 12' (min) (not required at grade)
	-	3	20' x 70'	17' X 12' (min) (not required at grade)

Table 1: Non-Custom Vault Dimensions Based on Type of Service and Equipment Needs

IV Maximum distance required is 3ft since all equipment will fit within that allocated space.

REFERENCE: NONE

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SCOPE: This design standard describes on grade single transformer vault requirements for 120/208V and 277/480V.

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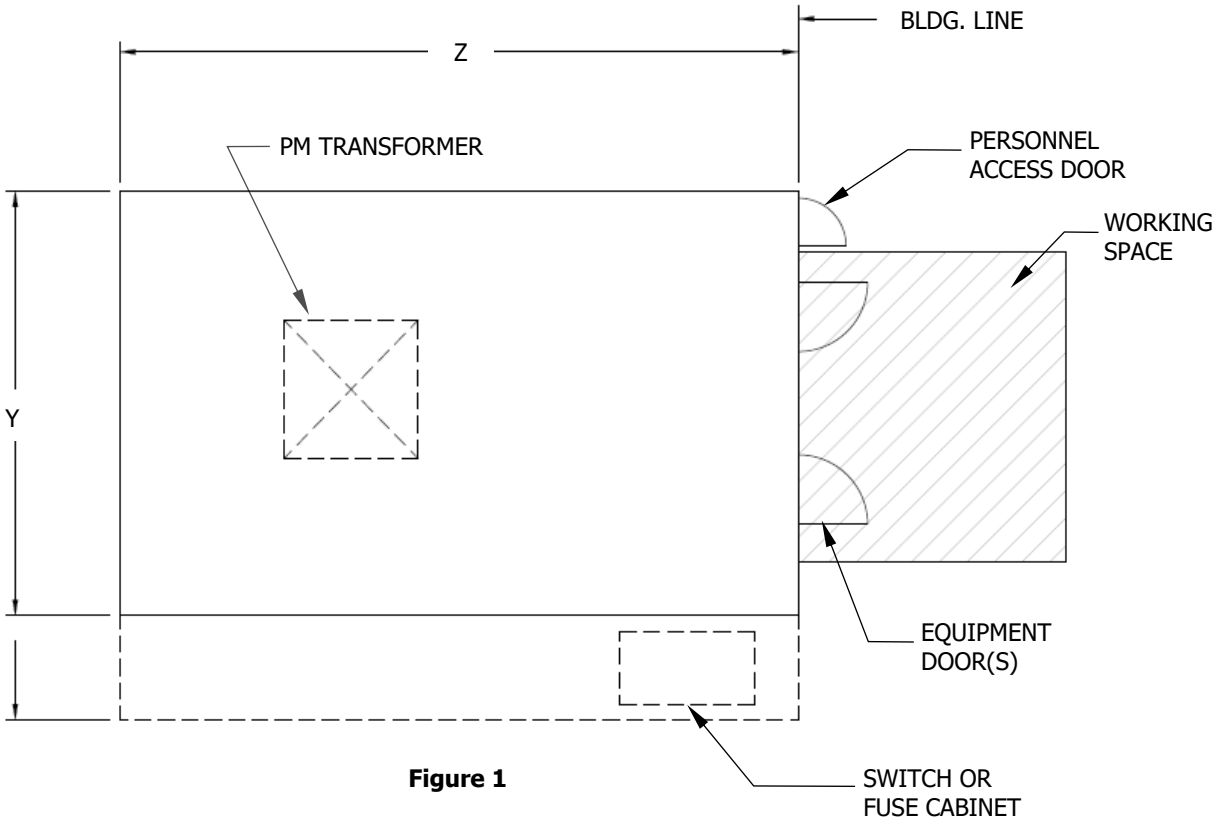


Figure 1

TABLE 1: ON GRADE
MINIMUM ELECTRIC VAULT REQUIREMENTS FOR
SINGLE TRANSFORMER INSTALLATION – 3-PHASE TRANSFORMER

CUST. BOARD SIZE	208V TRANSF. SIZE (KVA)	480V TRANSF. SIZE (KVA)	FRONT TO BACK LENGTH Z (II)	WALL TO WALL WIDTH Y	ALONG W/TRANSF. SWITCH INSTALLED ON SIDE WALL		FLOOR TO CEILING HEIGHT	ON GRADE EQUIPMENT OPENING		TRANSF. WEIGHT LBS	SUMP CAP. GALLONS	CLEAR & LEVEL WORKING SPACE IN FRONT OF EQUIP. OPENING	
					LENGTH Z	WIDTH Y		HEIGHT	WIDTH			DEPTH	WIDE
120/208V													
200	75	--	14′-6″	9′-6″	14′-6″	12′-6″	12′ Min – 20′ Max	10′-0″	8′-0″	3,500	240	10′-0″	8′-0″
400	150	--	14′-6″	9′-6″	14′-6″	12′-6″	12′ Min – 20′ Max			3,900	240		
600	225	--	16′-0″	9′-6″	16′-0″	12′-6″	12′ Min – 20′ Max			4,200	240		
800	300	--	17′-0″	10′-6″	17′-0″	13′-6″	12′ Min – 20′ Max			5,000	255		
1000	300	--	17′-0″	10′-6″	17′-0″	13′-6″	12′ Min – 20′ Max			5,000	255		
1200	500	--	19′-6″	12′-6″	19′-6″	12′-6″	12′ Min – 20′ Max			6,600	290		

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TABLE 1 (CONT'D):

TABLE 1: ON GRADE
MINIMUM ELECTRIC VAULT REQUIREMENTS FOR
SINGLE TRANSFORMER INSTALLATION – 3-PHASE TRANSFORMER

CUST. BOARD SIZE	208V TRANSF. SIZE (KVA)	480V TRANSF. SIZE (KVA)	FRONT TO BACK LENGTH Z (II)	WALL TO WALL WIDTH Y	ALONG W/TRANSF. SWITCH INSTALLED ON SIDE WALL		FLOOR TO CEILING HEIGHT	ON GRADE EQUIPMENT OPENING		TRANSF. WEIGHT LBS	SUMP CAP. GALLONS	CLEAR & LEVEL WORKING SPACE IN FRONT OF EQUIP. OPENING	
					LENGTH Z	WIDTH Y		HEIGHT	WIDTH			DEPTH	WIDE
120/208V													
1600	500	--	19′-6″	12′-6″	19′-6″	12′-6″	12′ Min – 20′ Max	10′-0″	8′-0″	6,600	290	10′-0″	8′-0″
2000	750	--	20′-0″	12′-6″	20′-0″	15′-6″	12′ Min – 20′ Max			7,550	425		
2500	1000	--	21′-0″	13′-6″	21′-0″	16′-6″	12′ Min – 20′ Max			8,200	435		
3000	1000	--	21′-0″	13′-6″	21′-0″	16′-6″	12′ Min – 20′ Max			8,200	435		
4000	1000 1500	--	23′-0″	16′-0″	23′-0″	19′-0″	12′ Min – 20′ Max			10,150	515		
277/480V													
200	--	150	14′-6″	9′-6″	14′-6″	12′-6″	12′ Min – 20′ Max	10′-0″	8′-0″	3,900	240	10′-0″	8′-0″
400	--	300	17′-0″	10′-6″	17′-0″	13′-6″	12′ Min – 20′ Max			5,000	255		
600	--	500	19′-6″	12′-6″	19′-6″	15′-6″	12′ Min – 20′ Max			6,600	290		
800	--	500	19′-6″	12′-6″	19′-6″	15′-6″	12′ Min – 20′ Max			6,600	290		
1000	--	750	12′-0″	12′-6″	20′-0″	15′-6″	12′ Min – 20′ Max			7,500	425		
1200	--	1000	21′-0″	13′-6″	21′-0″	16′-6″	12′ Min – 20′ Max			8,200	435		
1600	--	1000	21′-0″	13′-6″	21′-0″	16′-6″	12′ Min – 20′ Max			8,200	435		
2000	--	1500	23′-0″	16′-0″	23′-0″	19′-0″	12′ Min – 20′ Max			10,150	515		
2500	--	2000	23′-0″	16′-6″	23′-0″	19′-6″	12′ Min – 20′ Max			17,300	570		
3000	--	2000	23′-0″	16′-6″	23′-0″	19′-6″	12′ Min – 20′ Max			17,300	570		
4000	--	2500 3000	23′-0″	16′-6″	23′-0″	19′-6″	12′ Min – 20′ Max			17,300	580		

INSTALLATION: NONE

BILL OF MATERIALS: NONE

NOTES:

I. Dimensions in table 1 cover necessary work area including fusing equipment mounted on wall within 8ft work area in front of transformer.

(II) This dimension may be reduced by 6ft when the padmounted transformer is the only SDG&E equipment installed in vault and the clear and level working space requirement outside vault is maintained and at the same grade as vault floor.

III. For existing or legacy vault tables, see FMO DM5745.

REFERENCE: NONE

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SCOPE: This design standard describes on grade multiple transformer vault requirements for 120/208V and 277/480V.

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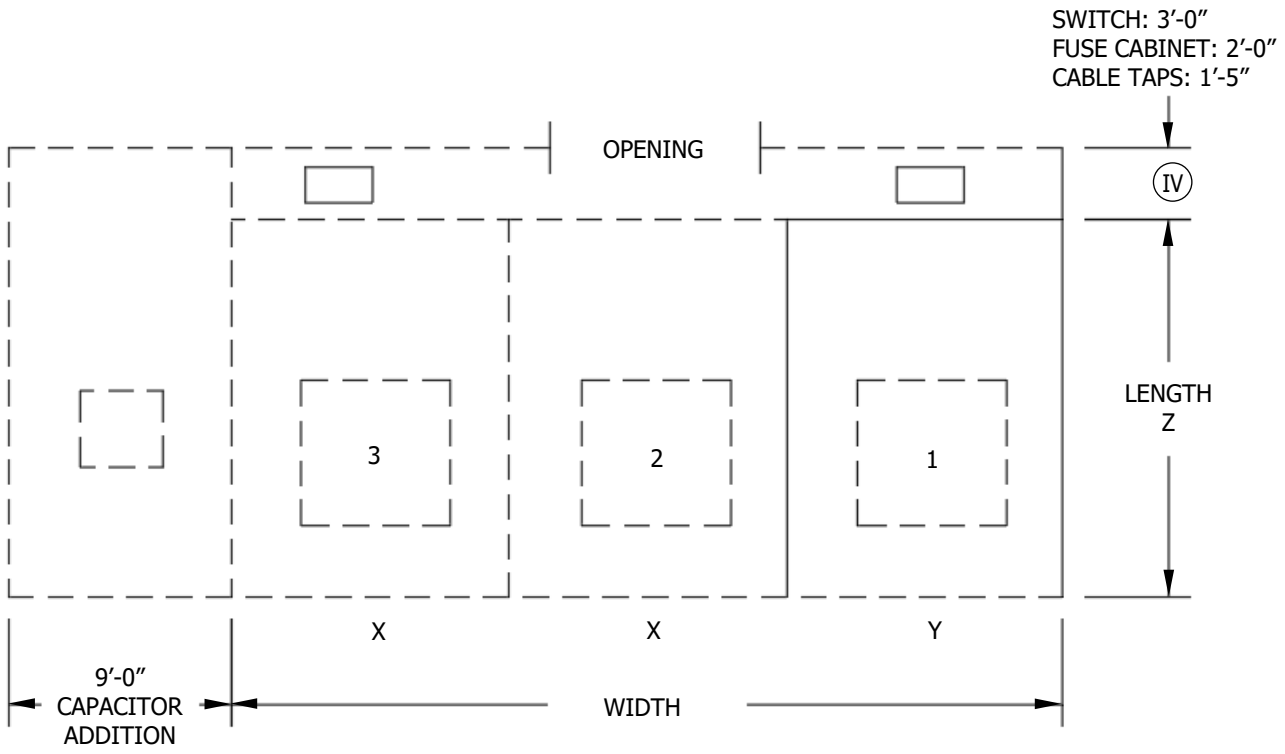


Figure 1

TABLE 1: ON GRADE MULTIPLE TRANSFORMER INSTALLATION
MINIMUM VAULT DIMENSIONS FOR MULTI-SERVICES (III)

120/208V SIDE BY SIDE	**MINIMUM VAULT DIMENSIONS FOR ONE SERVICE PANEL**										
	MAIN SIZE	**200i**	**400i**	**600i**	**800i**	**1000i**	**1200i**	**1600i**	**2000i**	**2500i**	**3000i**	**4000i**
	LENGTH Z	14'-6"	14'-6"	16'-0"	17'-0"	17'-0"	19'-6"	19'-6"	20'-0"	21'-0"	21'-0"	23'-0"
	WIDTH Y	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	13'-6"	16'-6"
	ADDITIONAL VAULT WIDTH FOR EACH ADDED SERVICE MAIN											
	WIDTH X	7'-6"	7'-6"	7'-6"	8'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"
277/480V SIDE BY SIDE	**MINIMUM VAULT DIMENSIONS FOR ONE SERVICE PANEL**											
	MAIN SIZE	**200i**	**400i**	**600i**	**800i**	**1000i**	**1200i**	**1600i**	**2000i**	**2500i**	**3000i**	**4000i**
	LENGTH Z	14'-6"	17'-0"	19'-6"	19'-6"	20'-0"	21'-0"	21'-0"	23'-0"	23'-0"	23'-0"	23'-0"
	WIDTH Y	9'-6"	10'-6"	12'-6"	12'-6"	12'-6"	13'-6"	16'-0"	16'-6"	16'-6"	16'-6"	16'-6"
	ADDITIONAL VAULT WIDTH FOR EACH ADDED SERVICE MAIN											
	WIDTH X	7'-6"	8'-6"	9'-6"	9'-6"	9'-6"	10'-6"	10'-6"	12'-0"	12'-6"	12'-6"	12'-6"

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INSTALLATION: NONE

BILL OF MATERIALS: NONE

NOTES:

I. To calculate multiple service vault dimension, start with largest applicable main size, then add appropriate footages for each additional service main.

II. In determining the number of equipment entry openings for slide-in or roll-in facilities, prime consideration shall be given to location and space required for switch, taps, and fuses mounted on or adjacent to walls. One equipment opening is sufficient if any one piece of equipment can be installed or removed via that opening without disturbing other equipment placed in vault.

(III) Dimensions are typical and may vary depending on customer's actual allocated space for vault. Rearranging facilities with necessary requirements to be worked out with project engineer.

(IV) Maximum distance required is 3ft since all equipment will fit within that allocated space.

REFERENCE: NONE

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SCOPE: This design standard describes the capacitor requirements for vaults.

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INSTALLATION: NONE

BILL OF MATERIALS: NONE

TABLE 1: CAPACITOR REQUIREMENTS FOR VAULTS

PANEL	200	400	600	800	1000	1200	1600	2000	2500	3000	4000
120/208 3Ø 4W	0	0	0	0	0	0	0	0	0	1	1
277/480 3Ø 4W	0	0	0	0	0	0	1	1	1	1	1

NOTES:

I. Add panel sizes by voltage class. Take the total and apply to the table. Round up to next size. When the total exceeds 4,000, allow for one padmounted capacitor and start over, adding the remaining panel ratings.

II. A "1" indicates vault space required for one padmounted capacitor.

III. A "0" indicates no capacitor required.

IV. Capacitor weight is 1,925 lbs.

REFERENCE: NONE

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SCOPE: This design standard describes supervisory control and data acquisition (SCADA) requirements.

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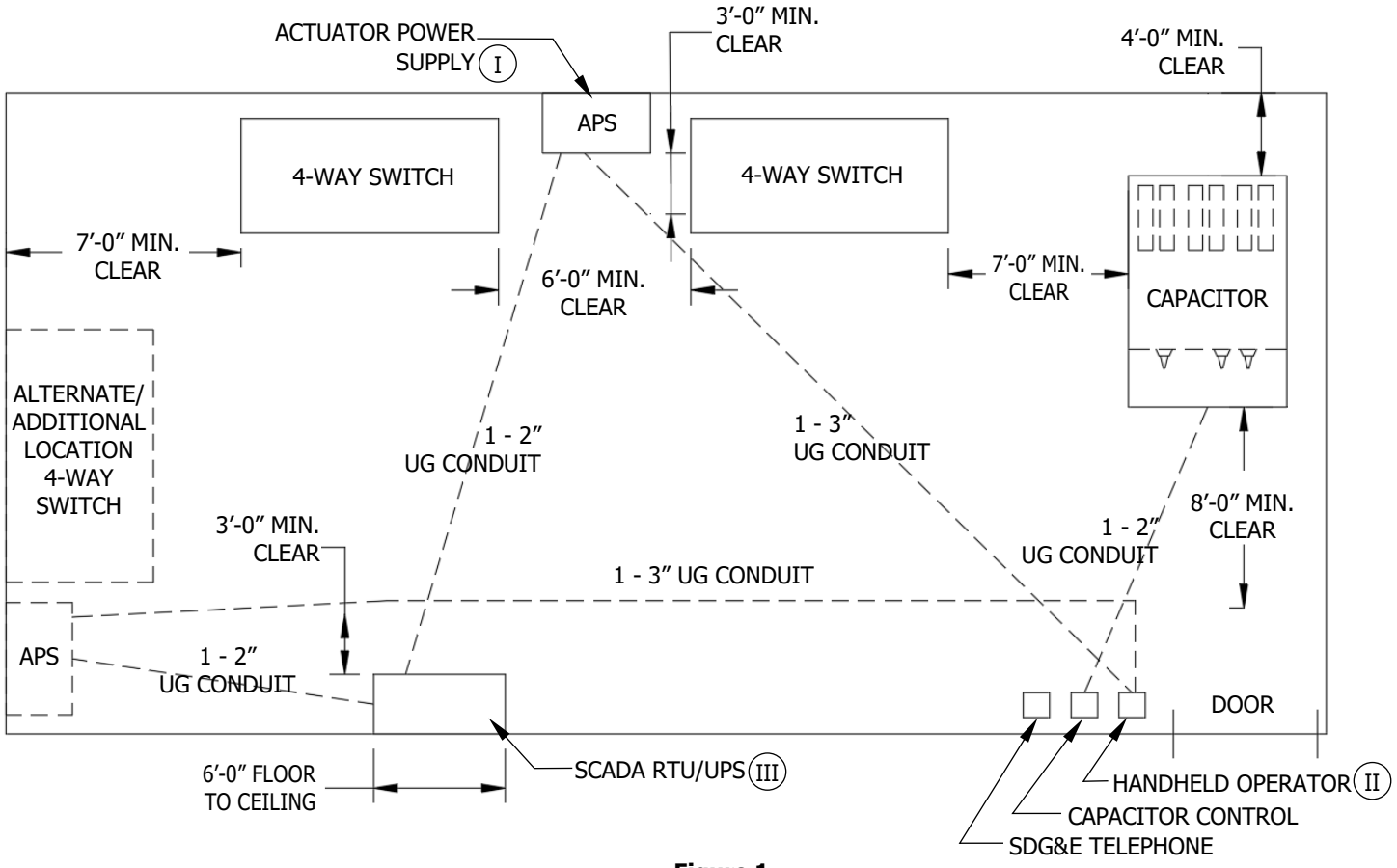


Figure 1
Typical SCADA Installation

INSTALLATION:

A. Install 50 pair cable "to split-66" terminal in all vaults for SDG&E telephone and SCADA, present or future.

B. In conduit package coming into the vault, install two 4in conduits above 5in conduits.

C. Install 120V service to feed SCADA RTU box. this may or may not require a 2in conduit, depending on the vault arrangement.

BILL OF MATERIALS: NONE

NOTES:

(I) One actuator power supply (aps) can control up to two 4-way switches. A third switch requires a second aps.

(II) One per switch. Connects to aps.

(III) 120V source required.

REFERENCE: NONE

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SCOPE: This design standard shows a 12 kV, 200A wall mounted fuse cabinet used for fusing in transformer vaults.

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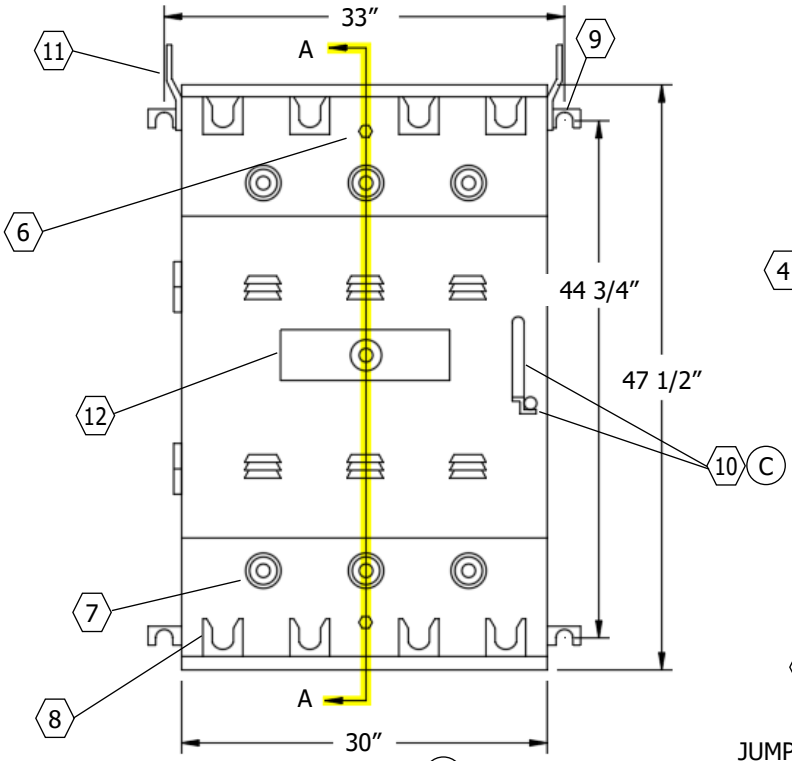


Figure 1 (1)
Front
See Table 2

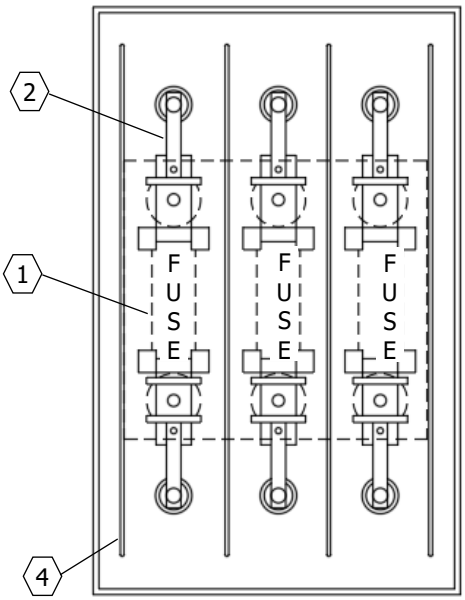


Figure 1
Front Section
See Table 2

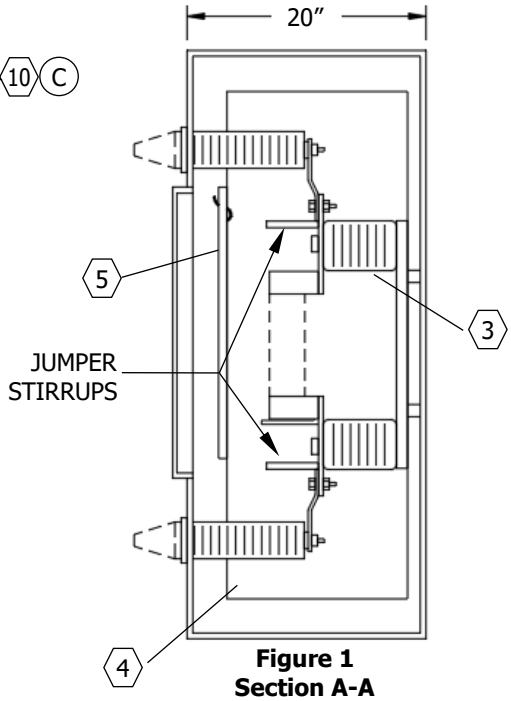


Figure 1
Section A-A
See Table 2

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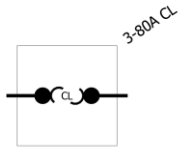
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TABLE 1: ELECTRIC RATINGS	
VOLTAGE	15KV
B.I.L.	110KV
MAX FUSE SIZE	200A

UG MAP SYMBOL



WALL-MOUNTED
FUSE CABINET

INSTALLATION:

(A) Bushing wells will accept bushing plug or feed-thru inserts for loadbreak capability. (2)(3)

(B) Install feed-thru inserts on load side of all cabinets.

(C) Cabinet door handle does not require a padlock.

BILL OF MATERIALS:

ITEM	DESCRIPTION	WEIGHT (LB)	QUANTITY	STANDARD PAGE	STOCK NUMBER	DESIGN UNITS
1	THREE-PHASE WALL MOUNTED FUSE CABINET	380	1	--	S190444	FC-VLT
2	PLUG, BUSHING	--	AS REQ'D	--	S544676	--
3	INSERT, FEED-THRU	--	AS REQ'D	--	S544678	--

TABLE 2: PARTS LIST	
ITEM	DESCRIPTION
1	200A CURRENT LIMITING FUSE (a)
2	COPPER BUS
3	BUSHING
4	BARRIER
5	REMOVABLE BARRIER
6	GROUNDING POSITION
7	BUSHING WELL (A)(B)
8	PARKING STAND
9	MOUNTING BRACKET
10	CABINET DOOR HANDLE AND PENTAHEAD BOLT PROVISION (B)
11	LIFTING TABS
12	MR OUCH DECAL
13	NAME PLATE (ON INSIDE OF DOOR) (II)

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NOTES:

I. Wall mounted fuse cabinet is delivered from the supplier with all the parts listed in table 2 except fuses.

(II) Not shown on figures.

REFERENCE:

(a) Underground Construction Standard 4302, Fuse Application Guide

b. See Transformer Vaults Specifications Book for Installation Location

c. Underground Construction Standard 3480, 3481, 3482, and 3483, Clearance in Front of Cabinet

d. Underground Construction Standard 3516, Three-Phase Wall Mounted Fuse Cabinet – 12kV, 200A

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

ELECTRIC VAULT DESIGN TABLES FOR SDG&E INTERNAL USE
THREE-PHASE WALL MOUNTED FUSE CABINET
12KV, 200A

SCOPE: This design standard provides equipment combination guidelines.

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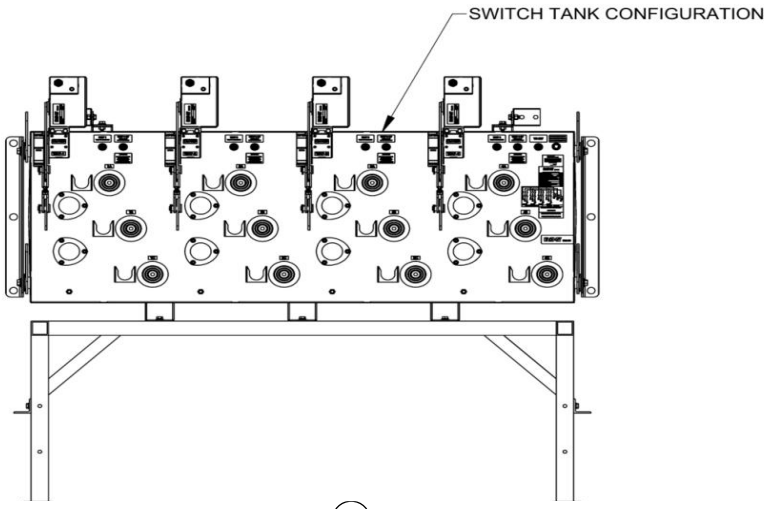


Figure 1 (III)
Walk-In Vaults
Typical 4-Way Vault-Mount Vacuum Fault Interrupting Manual or SCADA Switch

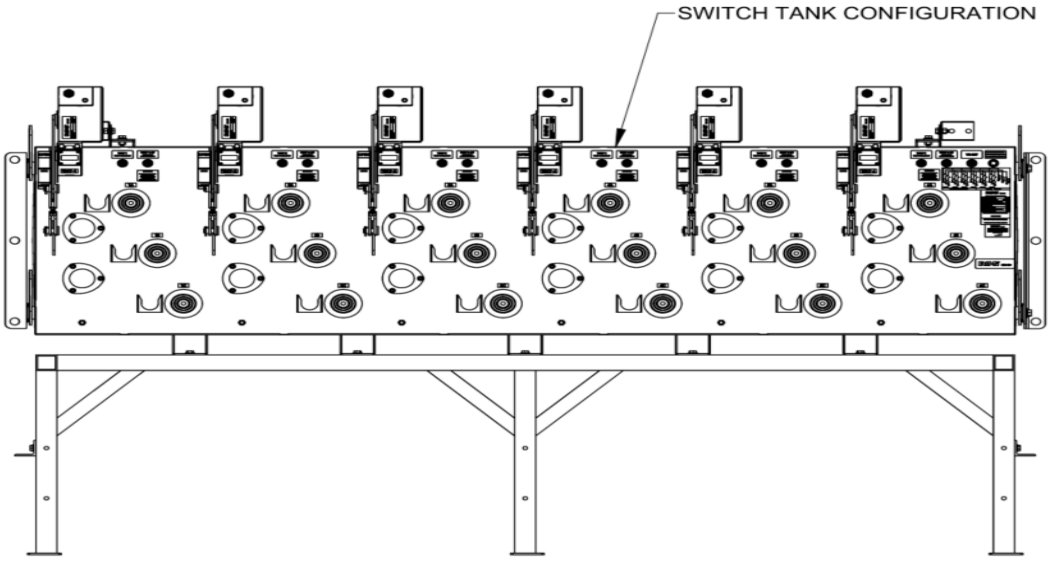


Figure 2 (III)
Walk-In Vaults
Typical 6-Way Vault-Mount ISG SCADA Switch

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INSTALLATION: NONE

BILL OF MATERIALS: NONE

NOTES:

I. Vault-Mount Vacuum Fault Interrupting switches are the preferred switch for vaults.

II. 4-way, 5-way and 6-way Vault-Mount Vacuum Fault Interrupting may be installed in dry vaults without a deviation request, if all required clearances are met.

(III) For all sizes of primary and secondary cables.

REFERENCE:

a. Underground Construction Standards 3677, Trayer Vault-Mounted Switchgear

b. Underground Construction Standards 3678, Trayer 3-Way Submersible Liquid Insulated Vacuum Switchgear

c. Underground Construction Standards 3679, Trayer 4-Way Grounded Vacuum Switch

d. Underground Construction Standards 3680, Innovative Switchgear Submersible and Vault-Mount

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5800
CAPACITORS

5800
CAPACITORS

PAGE	SUBJECT
5811	CAPACITOR APPLICATION CRITERIA

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SCOPE

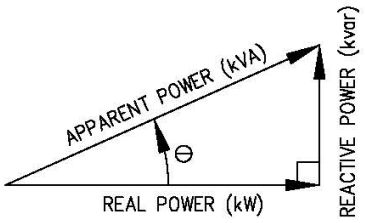
Electric Distribution Planning (EDP) and/or District Engineer(s) shall use the following criteria when designing and identifying capacitor station locations. The capacitor application criteria are provided to ensure proper placement and sizing of field capacitors to economically achieve the following benefits in this order of priority:

1. Maintain proper voltage levels and voltage rise limits.
2. Target circuit power factor at 0.995 lagging at the substation bus to reduce circuit load.
3. Minimize distribution line losses.

DEFINITIONS

- Power Factor - Ratio of real power (measured in kW) to the apparent power (measured in kVA). Apparent power (also known as demand) is the power used to operate the equipment. It is found by multiplying volts times amps (V x I).

$$PF = \frac{Real\ Power\ (kW)}{Apparent\ Power\ (kVA)}$$



- Load Power Factor - The load power factor prior to the addition of any capacitor(s).
- Lagging Load Power Factor - The power factor when the current follows the voltage (i.e. lagging the voltage). A lagging load consumes VARs, as in the case of inductive loads.
- Leading Load Power Factor - The Power Factor when the current precedes the voltage (i.e. leading the voltage). A leading load generates VARs, as in the case of capacitors or DER power inverters, or a synchronous motor operating in a leading mode
- Switched Capacitors - This includes capacitors with legacy controllers and SCADA-capable capacitors, where the capacitor station turns ON/OFF based on predetermined setpoints such as time or voltage threshold.
- Fixed Capacitor - This includes capacitors without a controller and switched and/or SCADA capacitors with a controller set with a constant ON setting. These types of capacitors are no longer installed. (Existing fixed capacitors are left in-service as long as the equipment remains in a healthy state.)

CAPACITOR TYPES AND SIZES AVAILABLE

- UG: The pad mounted, SCADA-switched capacitor station is available for 12 kV (600 kVAR or 1200 kVAR size) and 4 kV (150 kVAR or 300 kVAR sizes) applications.
- OH: Overhead 12 kV SCADA-switched capacitor stations are available in 600 or 1200 kVAR sizes. Overhead 4 kV SCADA switched capacitors are available in 150 kVAR or 300 kVAR sizes. (See OH Construction Standard 1314, Capacitor Connection.)
- SUB: The common 12 kV 7200 kVAR substation capacitor bank, installed at the 12 kV bus, is primarily used to compensate for substation transformer reactance and reduce var loading on the transformer. The capacitor bank is designed to operate in 4 stages of 1800 kVAR each or 2 stages of 3600 kVAR each.

APPLICATION

A. Capacitors Installed for Voltage Improvement
   1. The rise in voltage is due to the addition of shunt capacitors (i.e., voltage rise).

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Equation 1 is used to calculate the percentage increase of the voltage. A typical voltage profile and additional information regarding the effect of voltage rise due to the application of capacitors can be found in DM 6211, Distribution Circuit Voltage Profile.

Equation 1

$$\%V = (C)(X)\left(\frac{1}{1000}\right)$$

Where:

$\%V$ = Percent voltage rise at the capacitor bank.

C = Three-phase kVAR rating of the capacitor bank.

X= Per unit system line-to-neutral reactance at the capacitor location. (This may be obtained from the Synergi software.)

Figure 1 shows the expected voltage rise from a 1200 kVAR capacitor installed on the 12 kV overhead system. This utilizes an equivalent conductor spacing of 66.7 inches which is standard for a 10-foot crossarm construction. Figure 1 illustrates that for a 1200 kVAR capacitor, a 3% voltage rise is achieved at a distance between 4.5 to 6.0 miles from the substation, regardless of the overhead conductor size. This 4.5-to-6.0-mile range for 1200 kVAR capacitors must be considered when placing or replacing capacitor banks.

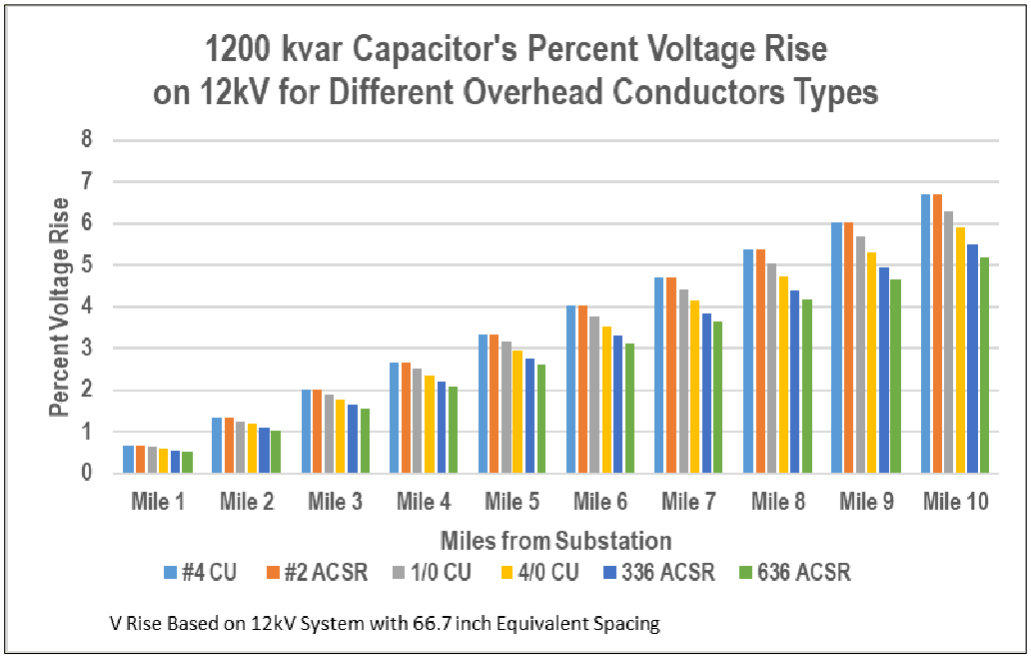


FIGURE 1
VOLTAGE EXPECTATION CHART

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Figure 2 shows the voltage rise for typical underground cables. As shown, the voltage rise per mile is much less than the overhead system due to the lower reactance for underground cables.

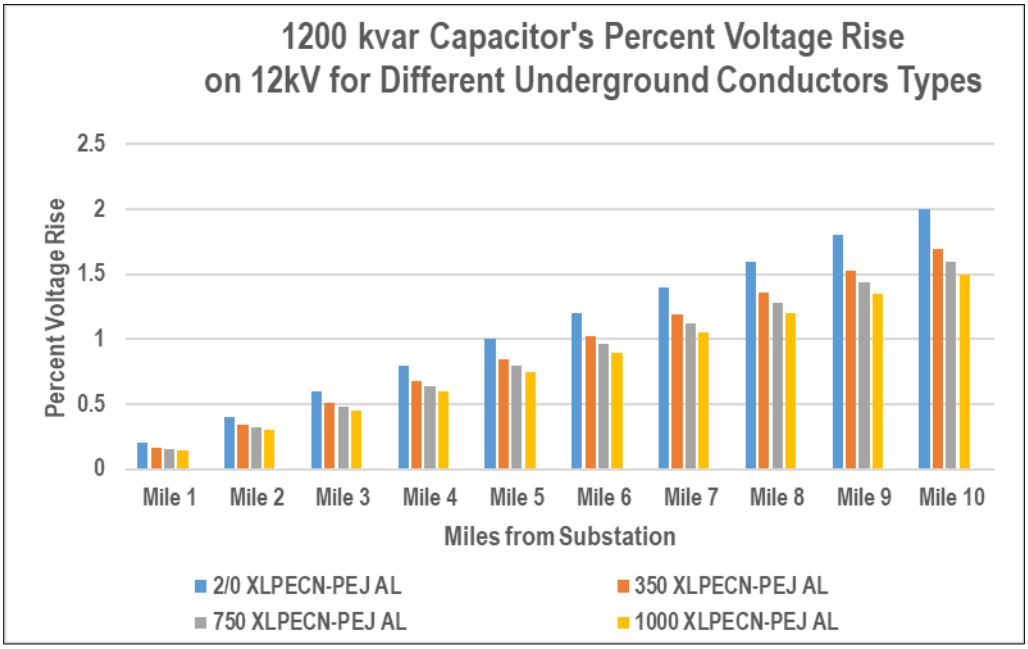


FIGURE 2
VOLTAGE RISE FOR UNDERGROUND CONDUCTORS

2. The voltage rise results from the addition of shunt capacitors calculated from Equation 1. The maximum primary voltage for CVR circuits is 123 volts on a 120-volt basis and 126 volts for non-CVR circuits.
3. For switched capacitors, the voltage rise at any single location shall be limited to 3% to avoid flicker problems.
4. For existing fixed capacitors, the cumulative voltage rise of all capacitors on any circuit shall not exceed 3%, with the following exception for non-CVR circuits only:
   a. The voltage rise may reach 5% if the circuit is modeled under multiple loading scenarios to confirm the voltage will not exceed 125 volts, and the capacitor has a controller set with a voltage override to turn the capacitor off if it exceeds 125 volts.
5. If the criteria for #1, #2, #3, and #4 cannot be achieved, then other voltage regulation solutions must be evaluated.

B. Capacitors Installed for Reactive Power Support

1. A 12 kV distribution circuit should have sufficient capacitors to correct the off-peak and on-peak power factor to the targeted 0.995 lag at the substation 12 kV bus. The actual uncorrected power factor for specific circuits should be used if available. If the actual uncorrected PF is not available, use 0.90 lag for summer peaking and 0.90 lag for winter peaking load. The kVAR needed to improve the power factor can be calculated as follows:

$$kVAR\ needed\ to\ correct\ to\ PF_2 = kVAR_1 - kVAR_2$$

Where:

$$kVAR_1 = kVA_1\ (\sin\ (cos^{-1}\ PF_1))$$
$$kVAR_2 = kVA_2\ (\sin\ (cos^{-1}\ PF_2))$$

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$$PF_1 = existing\ power\ factor$$

$$PF_2 = desired\ power\ factor$$

$$kVA_1 = kVA\ of\ load\ at\ initial\ PF$$

$$kVA_2 = kVA\ of\ load\ at\ improved\ PF$$

$$kVA_2 = kVA_1 * \left(\frac{PF_1}{PF_2}\right)$$

Example

A summer peaking circuit with no capacitors has a peak load of 400 amps. The power factor of this load is assumed to be 0.90 lag. The amount of kVAR needed to raise the power factor of this circuit to 0.995 lag can be calculated as follows:

$$kVAR_1 = (400\ A)\ (12\ kV)\ (1.732)\ (\sin(cos^{-1}\ 0.90)) = 3620\ kvar$$

$$kVAR_2 = (400\ A)\ (12\ kV)\ (1.732)\ \left(\frac{0.9}{0.995}\right)\ (\sin(cos^{-1}\ 0.995)) = 750\ kvar$$

$$kVAR\ needed\ to\ correct\ to\ PF_2 = (3620\ kvar) - (750\ kvar) = 2870\ kvar$$

Figure 3 provides the required kVAR to correct power to 0.995 using multiple kW values and different initial power factors.

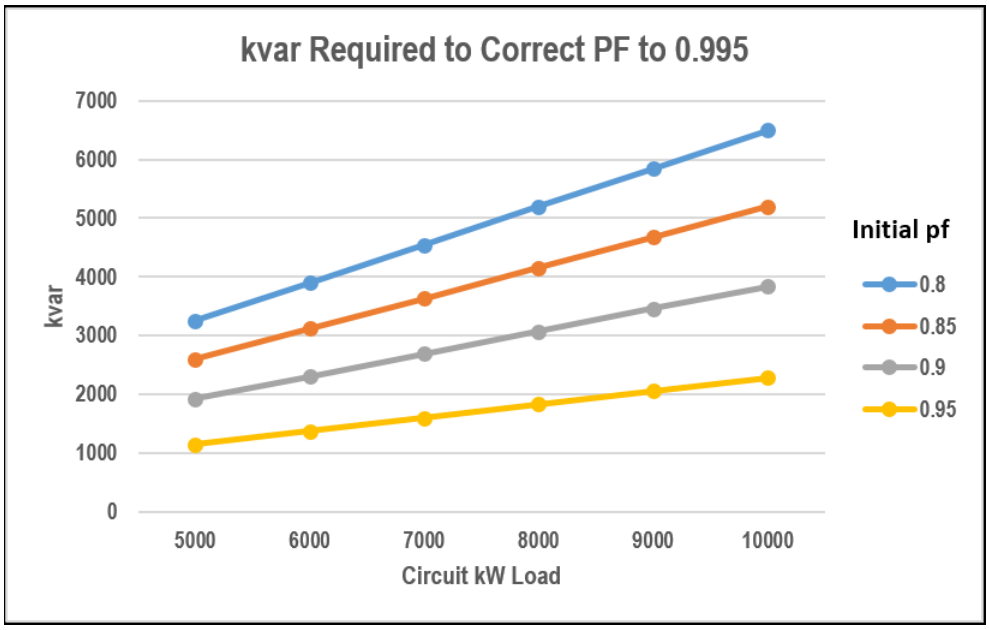


FIGURE 3

2. An individual substation 12 kV bus may be corrected to a leading power factor at peak, measured at the 12 kV bus, if it is necessary to accommodate a request from Transmission Planning or Grid Operations. The extent of the leading power factor to be established should be approved with Transmission Planning and/or Grid Operations.

   An average 12 kV feeder should have one capacitor designated "CM" suffix. Any additional capacitors should be operated with a "CW" suffix. A general rule is that the CM capacitor should not exceed about 30% of the total kVAR on a circuit that is expected to be seen during off-peak hours. The CW units will correct for loading above this base reactive loading. A CM suffix capacitor is one that is equipped with switched controls but is expected to operate in a default mode of "on" 24/7 barring

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extraordinary voltage excursions. A CW suffix capacitor is one that is operated in accordance with programmed switching instructions to correct for reactive loads above the base reactive load. Typically, a CW capacitor will operate on/off daily. If the circuit has sufficient capacitor kVAR installed, but actual kVAR information (i.e., substation SCADA) indicates a deficiency, contact the appropriate District Engineer to ensure all existing capacitors are in service and operating properly before adding new capacitors. SCADA data can also be utilized to confirm their operation. This will prevent excessive VARs from being added to the circuit that are not needed.

3. New capacitor installations are all SCADA-enabled, which allows multiple options for switching requirements, and the possibility of future centralized control.

4. The reactive power loss in a fully loaded 28 MVA substation transformer bank is 3.9 MVAR, calculated as follows:

$$Reactive\ Loss = I^2X \qquad where: I = \frac{28\ MVA}{15\ MVA} = 1.87\ p.u.$$

$$X = 7.5\ \%\ on\ a\ 15\ MVA\ base$$

$$Reactive\ Loss = (1.87)^2\ (0.075)\ (15\ MVA) = 3.9\ Mvar$$

Therefore, for every 28 MVA substation transformer bank that approaches its full load rating, there should be 4 MVAR of substation capacitance. The ultimate design rating of substation capacitors is 7.2 MVAR to offset the inability to place sufficient caps on the circuit.

5. A Distribution Planning Engineer will assess whether the current standard of 0.995 lag at the substation bus during peak is being met or if additional kVAR is needed along the feeder before a new location is approved.

C. Capacitor Location

1. Do not install capacitors on the load side of sectionalizing fuses or electronic sectionalizers. Do not install sectionalizing fuses or electronic sectionalizers on the line side of existing pole mounted capacitors . If a particular operation requires a capacitor to be installed past sectionalizing fuses or electronic sectionalizers, contact Electric Distribution Engineering. A Deviation Request must be submitted to document the decision to deviate from the recommended guideline.

2. The capacitor placement method is based on the minimum voltage being achieved. If capacitors are not sufficient to raise the voltage, other measures, such as voltage regulators or changing the Banks LTC's, may be required.

3. New capacitors should be placed utilizing the Voltage Imposed ½ Rule. This method is to be utilized with Synergi to properly model the kVAR flow and impact voltage rise. The generic ½ Rule is intended to place the capacitor where the kVAR flow would be split half upstream and half downstream. The Voltage Imposed ½ Rule adjusts the location to provide the proper voltage support as stated in A2 and A3 above. A flowchart to illustrate this process is shown in Figure 4.

4. For circuits with voltage regulators, Synergi simulation studies must account for their interaction with capacitors. To accurately determine the percent voltage rise when the capacitor switches on, the simulation model must place the regulator in manual mode temporarily. Otherwise, excessive voltage rise may be masked.

5. The minimum distance between capacitor banks should be no less than 1200 ft.

   a. There may be areas where the minimum distance is not feasible, therefore the Distribution Planning Engineer will need to obtain an approved Deviation Request from EDE.

   b. Example: When customers with large loads are added and system losses need to be compensated, work with EDP to determine if a capacitor is needed or other means such as a flywheel, etc.

6. Capacitor banks operating in fixed mode (CM suffix) should be placed in a location that minimizes base load losses. Physical constraints or the need for voltage correction may require an exception to the minimum loss location.

7. Capacitors should not be located on a pole at a highway or freeway crossing. The selected pole must be accessible by a bucket truck.

8. The pad mounted capacitor station should be installed (or right-of-way easement provisions made for future installations) in conjunction with new customer projects, when possible. The easement should be acquired in accordance with UG 3483,

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Minimum Operating Clearance Requirements For Pad Mounted And Subsurface Equipment, to ensure proper clearances. This will minimize retrofit installations that may adversely impact the customer.

9. Figure 4, New Capacitor Placement Process provides a flow chart describing the necessary steps when placing new Capacitor on the system.

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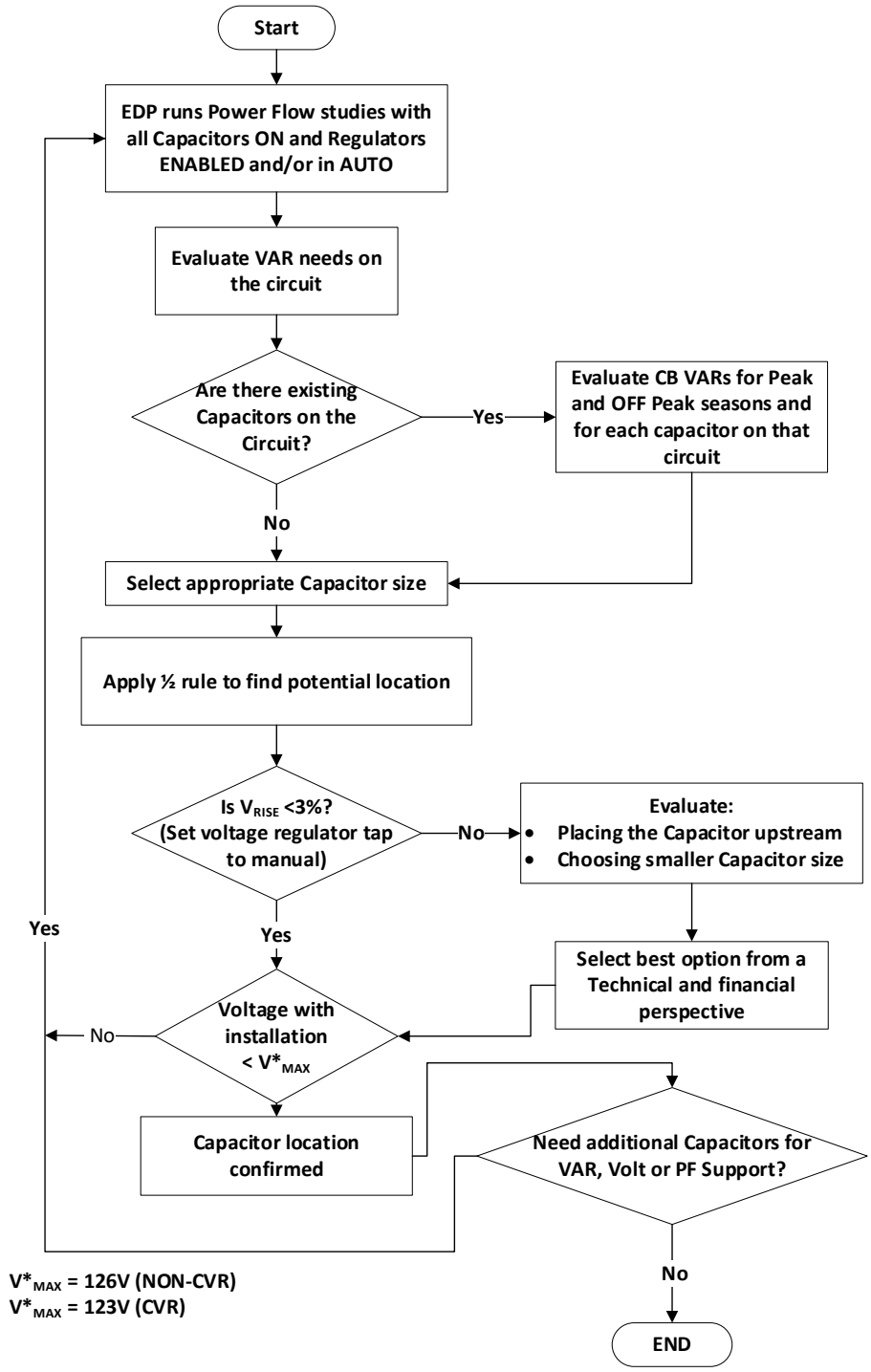


FIGURE 4
NEW CAPACITOR PLACEMENT PROCESS

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D. Connection

1. Every pad mounted capacitor station must be connected to a 4kV or 12kV primary system where the capacitor neutral is floating. Feed for a pad mounted capacitor station can be tapped directly from a 600-amp feeder, branch feeder, or a 200-amp local distribution branch. A pad mount capacitor cannot be the only load connected to a switch position of a PME, Trayer, Vista, or ISG Switch. The PME, Trayer, Vista, or ISG switches are not designed to switch capacitive loads.

2. The distance from the connection point to the pad mounted capacitor should be as short as practical when connecting directly to a 600-amp feeder. This is to minimize exposure to dig-in failure of the unfused line as well as reduce losses. However, it is recognized that in some cases, it may be impossible to install the capacitor close to the feeder yet still comply with traffic considerations, aesthetics, or other physical constraints.

3. When designing for a new capacitor installation, the designer must fill out the Capacitor Controller Settings Form (see Table 1) and include in the job package. EDP will review and provide the required capacitor controller settings for any existing and new capacitor installs.

   a. NOTE: For capacitor requiring SCADA work, a SCADA Request Form must be filled out.

      1) ERO will program No-SCADA Capacitor Controllers.

      2) Kearny will Program all SCADA Capacitor Controllers.

TABLE 1

CAPACITOR CONTROLLER SETTING FORM			
GENERAL SETUP AND CONTROL SCHEMES			**Available Schemes**
Summer Control Scheme	Winter Control Scheme	Low voltage Override (V)	Time switch
			Voltage only ON
Summer Start Date	Winter Start Date	High voltage Override (V)	Voltage only OFF
			kVAR (OH only)
Time Switch 1			
	Days of the week	Time of day ON	Time of day OFF
Schedule 1			
Schedule 2			
Time Switch 2			
	Days of the week	Time of day ON	Time of day OFF
Schedule 1			
Schedule 2			

kVAR control			
	Default	Custom	The difference between lagging and leading kVAR thresholds must be equal to 110% of 1-phase cell kVAR rating. The shown defaults apply to a 1,200 kVAR, 3-phase bank (400 kVAR / cell)
Lagging kVAR threshold (1-phase)	+ 220 kVAR		
Leading kVAR threshold (1-phase)	- 220 kVAR		
Voltage only control			
Preferred capacitor bank position		ON / OFF	
Fixed position control			
ON / OFF			

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C	Major Revisions	QTC	KNM	FRC	KRG	02/23/2024	F						
B	Editorial Changes	CSE	JCE	FRC	CZH	08/10/2020	E						
A	Editorial Changes	-	GB	-	-	05/16/2017	D						

E. SCADA Capacitor Controller Settings

1. Pole Mounted Capacitors - settings shall include:

   a. Volatge Control Override and kVAR Control or;

   b. Volatge Control Override or Time of Day (TOD) settings.

2. Padmount Capacitors – There are no Current Sensors available, therefore settings shall include:

   a. Voltage Control Override and Time of Day (TOD) settings.

F. Capacitor Survey

1. Each district should perform an annual survey of capacitor banks to verify proper operation. The GIS (Geographic Information System) Facilities File shall be updated by district engineers after the survey to serve as a planning tool for system kVAR maintenance. Details of the capacitor survey procedures are contained in the Electric Standard Practices 155, "Capacitor Survey."

REFERENCES

a. Underground Construction Standards 3483, Minimum Operating Clearance Requirements For Pad Mounted And Subsurface Equipment

b. Electric Standard Practices 155, Capacitor Survey

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A	Editorial Changes	-	GB	-	-	05/16/2017	D						

5900
WIRE & SUPPORTS

5900
WIRE & SUPPORTS

PAGE	SUBJECT
5911	OVERHEAD CONDUCTOR SAG
5912	OVERHEAD CONDUCTOR IMPEDANCES
5913	UNDERGROUND 600V CABLE IMPEDANCES
5921	CABLE PULLING TENSIONS, PRIMARY AND SECONDARY
5922	CABLE TAIL LENGTH REQUIREMENTS
5923	UNDERGROUND CABLE INSTALLATION CRITERIA

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C							F						
B	DM5931 MOVED TO FMO	YZZ	LY	FRC	FRC	08/18/2026	E						
A	REVISION	-	-	-	CAK	01/01/1998	D						

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SCOPE

This design standard provides Overhead Conductor SAG Criteria.

PURPOSE

Initial and final sag calculations are necessary to ensure sufficient clearance (based on GO95 requirements) will exist between conductors at different levels. In addition, the final sag calculation is necessary to ensure there is adequate ground clearance from the lowest conductor.

DEFINITIONS

Initial Sag – amount of conductor sag in feet and inches at the time conductor is installed.

Catenary Curve – refers to a template constructed to a scale of 1"=200' horizontally and 1"=50' vertically.

Catenary Number – refers to the number assigned to a particular Catenary Curve which depicts the overhead conductor sag to a known scale.

* Final Sag – refers to the amount of conductor sag (at a given temperature) that will occur 10 years after the conductor has been installed.

* Final Tension – refers to the final conductor tension (at a given temperature) used to calculate a Catenary Curve identification number.

Loading District – refers to Light, Medium, Heavy or Extra Heavy as defined by General Order 95. The Light Loading District applies to parts of San Diego and Orange Counties with an elevation between 0–3000 feet, medium 3000–4500 feet, heavy applies above 4500 feet. The Extra Heavy Loading District applies only to unprotected areas on Palomar and Volcan Mountains.

Actual Ruling Span – refers to the theoretical span length in which the changes in conductor tension, due to changes in temperature and loading, will most nearly agree with the average tension in a series of spans of varying length, AND with flexible supports (poles) between dead ends. See equation 1 on 5911.3 .

Approximate Ruling Span – Ruling Span, closest in value to the actual Ruling Span, found in the Design Tables section of the Overhead Sag and Tensions Standards.

Standard Pin Spacing – pin spacing specified in Overhead Standard 382 & 383 for crossarms. Modification of Standard Pin Spacing on crossarms will require re–calculation of published vertical and horizontal loading factors.

CRITERIA

A. Sag Table Application

1. Sag and tension data and tables can be found in the Overhead Sag and Tensions Standards. The standards are published by the Electric Distribution Standards Dept.

2. Use the sag tables found in the Overhead Sag and Tensions Standards for ruling spans of 150', 200', 300' & 400' (500' for AWAC). Electric Distribution Standards will prepare special sag tables for those ruling spans not found in the manual. The following information will be needed to prepare a special sag table:

   a. Wire size and type
   b. Ruling span
   c. Initial tension
   d. Loading district
   e. Maximum and minimum span length

   One copy of the specially prepared sag table shall be attached to the work order package sent to the Construction Department. Another copy should be placed in the Design file folder.

* Find these values in the Design Tables section of the Overhead Sag and Tensions Standard.

CRITERIA (continued)

A. Sag Table Application

3. The Ruling Span must be calculated prior to using the sag tables or whenever a special sag table is prepared. Equation 1 in Table 1, on 5911.3, should be used to calculate the ruling span.

B. Catenary Curve Usage

Catenary curves are stored, for common use, as follows:

Electric Systems Design Resource Center
Metro Resource Center
Northern Resource Center
Orange County District Office – with Geoff Lehy

Equation 2 in Table 1, on 5911.3, should be used to calculate the Catenary numbers. See 'Selecting Catenary Curves', step 2a in the sample problem on 5911.4 .

C. Reduced Tension Spans

1. A lower anchor guy tension may be achieved by using multiple guys in combination with a reduced tension span. A typical example is shown in Figure 1.

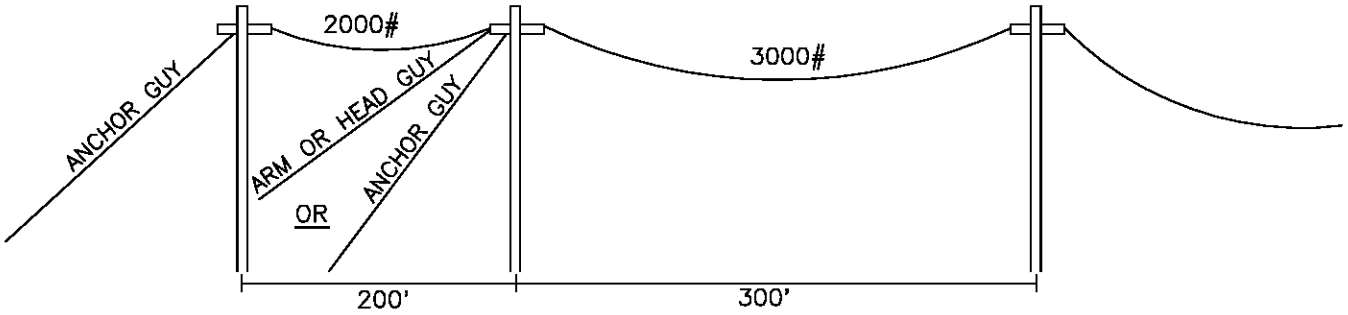


FIGURE 1

2. Ruling Spans of 200 feet or less have less sag at rated tension due to the span length and, therefore, may be installed as reduced tension without creating G095 clearance problems.

3. Reduced tension ruling spans require a sag table for the particular tension being used. Electric Distribution Standards will prepare this sag table and the Designer shall attach the stringing table to the work order for Construction Department use.

D. Sag

Sag is determined from the sag tables in the Overhead Sag and Tensions Standards Manual. USE the DESIGN TABLES section FOR SYSTEM DESIGN. The Initial and Final Sag Tables, the second section, is for construction use only

E. Conductor Separation / Pin Spacing

Multiple conductors on the same crossarm must maintain a certain horizontal separation to prevent the wires from slapping together. This amount of separation is known as minimum Pin Spacing and is calculated using Equation 3 in Table 1, on 5911.3.

TABLE 1
(Sag Related Equations)

Actual Ruling Span = $\sqrt{\dfrac{S_1^3 + S_2^3 + S_3^3 \ldots + S_n^3}{S_1 + S_2 + S_3 \ldots + S_n}}$ Equation 1

Where:

$\sqrt{}$ = Mathematical symbol for 'take the square root of'. Applies to any number or equation contained within the symbol.

S = number of feet in a span.

S_1 = number of feet in span number 1

n = number of spans involved in the Ruling Span equation.

S_1^3 = number of feet in span number 1 raised to the 3rd power (cubed).

* Catenary number = $\dfrac{\text{Final Tension}}{\text{[Conductor] Weight}} - \text{Final Sag}$ Equation 2

Where:

Final Tension = Final conductor tension at a given temperature for the Approximate Ruling Span. Found in the Design Tables section (DTs) of the Overhead Sag and Tension Standards (OSTS).

[Conductor] Weight = Weight of conductor at a given temperature for the Approximate Ruling Span. Found in the DTs of the OSTS.

Final Sag = Final sag at a given temperature for the Approximate Ruling Span. Found in the DTs of the OSTS.

* GO 95 rule 43 states that "maximum temperature shall be assumed to be 130° F in computing sag". Select the proper table in the DTs of the OSTS. USE the FINAL TENSION, [Conductor] WEIGHT, and FINAL SAG factors (from the table selected) ASSOCIATED WITH 130° F to calculate a catenary number FOR a HOT CURVE.

When uplift is a concern, make an additional calculation using the "Design Conditions" temperature (either 0° or 25° F, depending on the Loading District; see OHS 340). Select the proper table in the DTs of the OSTS. USE the FINAL TENSION, [Conductor] WEIGHT, and FINAL SAG factors (from the table selected) ASSOCIATED WITH THE DESIGN CONDITIONS TEMPERATURE to calculate a catenary number FOR a COLD CURVE.

Pin Spacing = $8\sqrt{\text{Final Sag}} + 3.5$ Equation 3

Where:

Pin Spacing = Minimum pin spacing required, in inches.

Final Sag = In feet, at 130° (GO 95 rule 43), for the Approximate Ruling Span. Found in the DTs section of the OSTS.

SAMPLE PROBLEM: Find the Catenary number, and the Pin Spacing required, for a new line constructed with 4/c # 636 ACSR/AW conductor, at 3000# tension, in heavy loading district, having five spans whose lengths are: 250', 280', 270', 300', and 350'.

Step 1. Determine the Actual Ruling Span for the line.

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SAMPLE PROBLEM (continued)

Step 1.

* Actual Ruling Span $= \sqrt{\dfrac{250^3 + 280^3 + 270^3 + 300^3 + 350^3}{250 + 280 + 270 + 300 + 350}} = \sqrt{\dfrac{127{,}135{,}000}{1450}}$

$= \sqrt{87{,}697.3} = 296.1 = 296 =$ Actual Ruling Span

* Raising numbers to the 3rd power, addition of the resulting values, division and taking of square roots can easily be accomplished using any simple hand held calculator.

Step 2. Using the value calculated for the Actual Ruling Span in step 1, select an Approximate Ruling Span, closest in value, from the DTs in the OSTS. Using the data from the table for the Approximate Ruling Span, calculate the Catenary number and Pin Spacing.

2a.

With a value of 296 for the Actual Ruling Span select an Approximate Ruling Span of 300'. In the DTs of the OSTS can be found a 300' Ruling Span [Heavy Loading] table for 636 ACSR/AW Tension 3000 lbs. Use the data found in the table (at the GO 95 required temperature of 130°) to solve the Catenary number equation for a HOT CURVE. If needed, calculate a second Catenary number using the Design Conditions temperature (in this case: 0° F for Heavy Loading) to solve the Catenary number equation for a COLD CURVE.

$$\text{Catenary number} = \frac{\text{Final Tension}}{\text{[Conductor] Weight}} - \text{Final Sag}$$

HOT CURVE: Final Tension = 942 [Conductor] Weight = .786 Final Sag = 9.43

HOT CURVE Catenary number $= \dfrac{942}{.786} - 9.43 = 1189.04 = 1189$

COLD CURVE: Final Tension = 2968 [Conductor] Weight = 1.970 Final Sag = 7.49

COLD CURVE Catenary number $= \dfrac{2968}{1.970} - 7.49 = 1499.01 = 1499$

Selecting Catenary Curves:

Select a Catenary Curve with an identifying number within 50 units ± of the calculated Catenary number. If the Catenary number is not within 50 units ± of a exiting Catenary Curve identifying number, select a Catenary Curve with an identifying number closest and below the Catenary number calculated.

2b. Calculate minimum Pin Spacing required using the value for Final Sag already selected (9.43).

Pin Spacing $= 8\sqrt{\text{Final Sag}} + 3.5 = 8\sqrt{9.43} + 3.5 =$

$= 8 \quad (3.07) \quad + 3.5 = 28.06 =$ 28 (inches)

Use the mininum Pin Spacing calculated to confirm or select crossarms for the intended construction. See Overhead Standards 381 & 382 to select crossarms with the required pin spacing, based on vertical loading criteria. See Overhead Standard 383 & 384 to select crossarms with the required pin spacing, based on horizontal loading criteria. Modification of the Standard Pin Spacing specified in the OH Standards will require re-calculation of the published vertical and horizontal loading factors.

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SDG&E DISTRIBUTION DESIGN MANUAL

OVERHEAD CONDUCTOR IMPEDANCES

5912.1

12.47kV WIRE IMPEDANCES (2)

% IMPEDANCE/1000', 20 MVA BASE

POSITIVE SEQUENCE (Z^+)
ZERO SEQUENCE (Z^o)

Equivalent Spacing, D_E (1)

Conductor Size	31"	36.0"	46.8"	66.7"	82.5"	103.3"
1033.5 MCM ACSR	.221 + j1.22 .919 + j7.41	.221 + j1.26 .919 + j7.32	.221 + j1.34 .919 + j7.17	.221 + j1.44 .919 + j6.96	.221 + j1.51 .919 + j6.83	.221 + j1.57 .919 + j6.70
636 MCM ACSR	.358 + j1.29 1.06 + j7.48	.358 + j1.34 1.06 + j7.40	.358 + j1.41 1.06 + j7.24	.358 + j1.52 1.06 + j7.03	.358 + j1.58 1.06 + j6.91	.358 + j1.65 1.06 + j6.77
500 MCM CU	.291 + j1.36 .989 + j7.56	.291 + j1.41 .989 + j7.47	.291 + j1.49 .989 + j7.31	.291 + j1.59 .989 + j7.10	.291 + j1.65 .989 + j6.98	.291 + j1.72 .989 + j6.85
394.5 MCM AL	.660 + j1.40 1.36 + j7.59	.660 + j1.44 1.36 + j7.50	.660 + j1.52 1.36 + j7.35	.660 + j1.63 1.36 + j7.14	.660 + j1.69 1.36 + j7.01	.660 + j1.75 1.36 + j6.88
336.4 MCM ACSR	.677 + j1.38 1.37 + j7.57	.677 + j1.42 1.37 + j7.48	.677 + j1.50 1.37 + j7.33	.677 + j1.61 1.37 + j7.12	.677 + j1.67 1.37 + j6.99	.677 + j1.73 1.37 + j6.86
4/0 CU	.677 + j1.51 1.37 + j7.70	.677 + j1.55 1.37 + j7.61	.677 + j1.63 1.37 + j7.46	.677 + j1.73 1.37 + j7.25	.677 + j1.80 1.37 + j7.12	.677 + j1.86 1.37 + j6.99
3/0 ACSR	1.36 + j1.60 2.06 + j7.79	1.36 + j1.64 2.06 + j7.70	1.36 + j1.72 2.06 + j7.55	1.36 + j1.82 2.06 + j7.34	1.36 + j1.89 2.06 + j7.21	1.36 + j1.95 2.06 + j7.08
2/0 CU	1.07 + j1.58 1.77 + j7.77	1.07 + j1.62 1.77 + j7.68	1.07 + j1.70 1.77 + j7.53	1.07 + j1.80 1.77 + j7.32	1.07 + j1.87 1.77 + j7.19	1.07 + j1.93 1.77 + j7.06
1/0 CU	1.35 + j1.61 2.05 + j7.80	1.35 + j1.65 2.05 + j7.72	1.35 + j1.73 2.05 + j7.56	1.35 + j1.84 2.05 + j7.35	1.35 + j1.90 2.05 + j7.23	1.35 + j1.97 2.05 + j7.09

5912.2

OVERHEAD CONDUCTOR IMPEDANCES

SDG&E DISTRIBUTION DESIGN MANUAL

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12.4KV WIRE IMPEDANCES (2)

POSITIVE SEQUENCE (Z^+)
ZERO SEQUENCE (Z^o)
Equivalent Spacing, D_E (1)

Conductor Size	31"	36.0"	46.8"	66.7"	82.5"	103.3"
#6 CU	5.38 + j1.81 / 6.08 + j8.00	5.38 + j1.85 / 6.08 + j7.92	5.38 + j1.93 / 6.08 + j7.76	5.38 + j2.04 / 6.08 + j7.55	5.38 + j2.10 / 6.08 + j7.42	5.38 + j2.17 / 6.08 + j7.29
#4 CU	3.38 + j1.74 / 4.08 + j7.93	3.38 + j1.78 / 4.08 + j7.84	3.38 + j1.86 / 4.08 + j7.69	3.38 + j1.97 / 4.08 + j7.48	3.38 + j2.03 / 4.08 + j7.35	3.38 + j2.10 / 4.08 + j7.22
#2 ACSR	3.43 + j1.72 / 4.13 + j7.92	3.43 + j1.77 / 4.13 + j7.83	3.43 + j1.84 / 4.13 + j7.67	3.43 + j1.95 / 4.13 + j7.46	3.43 + j2.01 / 4.13 + j7.34	3.43 + j2.08 / 4.13 + j7.20
#2 CU	2.15 + j1.68 / 2.85 + j7.87	2.15 + j1.72 / 2.85 + j7.78	2.15 + j1.80 / 2.85 + j7.63	2.15 + j1.91 / 2.85 + j7.42	2.15 + j1.97 / 2.85 + j7.29	2.15 + j2.03 / 2.85 + j7.16
#1 CU	1.70 + j1.64 / 2.40 + j7.84	1.70 + j1.69 / 2.40 + j7.75	1.70 + j1.77 / 2.40 + j7.59	1.70 + j1.87 / 2.40 + j7.38	1.70 + j1.93 / 2.40 + j7.26	1.70 + j2.00 / 2.40 + j7.13
TWIN CIRCUIT 394.5 MCM AL	.0329 + j.697 / 1.023 + j6.454					

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SDG&E DISTRIBUTION DESIGN MANUAL

OVERHEAD CONDUCTOR IMPEDANCES

5912.3

4.16kV WIRE IMPEDANCES
% IMPEDANCE/1000', 20 MVA BASE

POSITIVE SEQUENCE (Z^+)
ZERO SEQUENCE (Z^o)

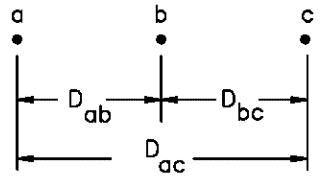
Equivalent Spacing, D_E (1)

Conductor Size _____	17.2"	18.3"	37.1"	53.3"
4/0 CU	5.62 + j11.0 11.4 + j66.7	5.62 + j11.2 11.4 + j66.4	5.62 + j12.9 11.4 + j63.0	5.62 + j13.8 11.4 + j61.2
2/0 CU	8.89 + j11.6 14.7 + j67.3	8.89 + j11.8 14.7 + j67.0	8.89 + j13.5 14.7 + j63.6	8.89 + j14.4 14.7 + j61.8
1/0 CU	11.2 + j11.9 17.0 + j67.6	11.2 + j12.1 17.0 + j67.3	11.2 + j13.8 17.0 + j63.8	11.2 + j14.7 17.0 + j62.1
#6 CU	44.6 + j13.6 50.4 + j69.3	44.6 + j13.7 50.4 + j69.0	44.6 + j15.5 50.4 + j65.5	44.6 + j16.3 50.4 + j63.7
#4 CU	28.0 + j13.0 33.8 + j68.7	28.0 + j13.1 33.8 + j68.4	28.0 + j14.9 33.8 + j64.9	28.0 + j15.8 33.8 + j63.1
#2 CU	17.8 + j12.5 23.6 + j68.2	17.8 + j12.6 23.6 + j67.9	17.8 + j14.4 23.6 + j64.4	17.8 + j15.3 23.6 + j62.6
#1 CU	14.1 + j12.2 19.9 + j67.9	14.1 + j12.3 19.9 + j67.6	14.1 + j14.1 19.9 + j64.1	14.1 + j15.0 19.9 + j62.3

NOTES:

(1) Equivalent Spacing, D_E

$$D_E = \left(D_{ab} \times D_{bc} \times D_{ac} \right)^{1/3}$$



(2) 4kV impedances can be obtained by multiplying the 12.47kV impedances by 8.32.

4kV impedances with old 4kV spacing is available on page 5643.3.

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12.47kV UNDERGROUND CABLE IMPEDANCES

PERCENT IMPEDANCE/1000 FEET, 20 MVA BASE

Triplex Cable Configuration

Positive Sequence (Z^+)
Zero Sequence (Z_o)

	1 Circuit	2 Circuits Paralleled
Aluminum		
3–1/c 1000 KCMIL AL XLPECN–PEJ	0.367 + j0.415 1.064 + j0.303	0.183 + j0.208 0.535 + j0.136
3–1/c 750 KCMIL AL XLPECN–PEJ	0.443 + j0.436 1.337 + j0.360	0.222 + j0.218 0.674 + j0.157
3–1/c 750 KCMIL AL COMP. EPR–PEJ	0.388 + j0.282 2.328 + J0.675	
3–1/c 350 KCMIL AL XLPECN	0.834 + j0.492 2.895 + J0.820	0.417 + j0.246 1.497 + j0.304
3–1/c #2/0 AL XLPECN	2.137 + j0.561 6.162 + j2.718	1.069 + j0.281 3.535 + j1.00
3–1/c #2 (solid) AL XLPECN	4.292 + j0.610 7.561 + j1.75	2.146 + j0.305 3.971 + j0.632
COPPER		
3–1/c 500 KCMIL CU PECN	0.394 + j0.476 1.189 + j0.387	0.197 + j0.238 0.598 + j0.175
3–1/c #4/0 CU PECN	0.808 + j0.542 2.777 + j0.829	0.404 + j0.271 1.431 + j0.318
3–1/c #2 CU PECN	2.494 + j0.649 4.639 + j1.051	1.247 + j0.324 2.372 + j0.415
3–1/c #4 CU PECN	3.972 + j0.682 7.123 + j1.722	1.986 + j0.341 3.731 + j0.634

ASSUMPTIONS:

a) Conductor and concentric neutral wire temperatures are 90° C and 70° C, respectively, for aluminum cables.

b) Conductor and concentric neutral wire temperatures are 75° C and 55° C, respectively, for copper cables.

c) Insulation thicknesses of 175 and 220 mils are used, respectively, for aluminum and copper cables.

d) These impedance values are correct for both jacketed and non-jacketed cables.

e) Positive and negative sequence impedances are equal.

f) For two circuits in parallel, 7.5 inch spacing (between the duct centers) is used.

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600V ALUMINUM CABLE L–N IMPEDANCE TABLE

CABLE TYPE	1 RUN R	1 RUN X	2 RUNS R	2 RUNS X	3 RUNS R	3 RUNS X
#2	0.3390	0.0450	0.1695	0.0225	0.1130	0.0150
1/0	0.2120	0.0440	0.1060	0.0220	0.0707	0.0147
3/0	0.1380	0.0420	0.0690	0.0210	0.0460	0.0140
350kcmil	0.0650	0.0400	0.0325	0.0200	0.0217	0.0133
500kcmil	0.0460	0.0390	0.0230	0.0195	0.0153	0.0130
1000kcmil	0.0240	0.0370	0.0120	0.0185	0.0080	0.0123

CABLE TYPE	4 RUNS R	4 RUNS X	5 RUNS R	5 RUNS X	6 RUNS R	6 RUNS X
#2	0.0848	0.0113	0.0678	0.0090	0.0565	0.0075
1/0	0.0530	0.0110	0.0424	0.0088	0.0353	0.0073
3/0	0.0345	0.0105	0.0276	0.0084	0.0230	0.0070
350kcmil	0.0163	0.0100	0.0130	0.0080	0.0108	0.0067
500kcmil	0.0115	0.0098	0.0092	0.0078	0.0077	0.0065
1000kcmil	0.0060	0.0093	0.0048	0.0074	0.0040	0.0062

CABLE TYPE	7 RUNS R	7 RUNS X	8 RUNS R	8 RUNS X	9 RUNS R	9 RUNS X
#2	0.0484	0.0064	0.0424	0.0056	0.0377	0.0050
1/0	0.0303	0.0063	0.0265	0.0055	0.0236	0.0049
3/0	0.0197	0.0060	0.0173	0.0053	0.0153	0.0047
350kcmil	0.0093	0.0057	0.0081	0.0050	0.0072	0.0044
500kcmil	0.0066	0.0056	0.0058	0.0049	0.0051	0.0043
1000kcmil	0.0034	0.0053	0.0030	0.0046	0.0027	0.0041

CABLE TYPE	10 RUNS R	10 RUNS X	11 RUNS R	11 RUNS X	12 RUNS R	12 RUNS X
#2	0.0339	0.0045	0.0308	0.0041	0.0283	0.0038
1/0	0.0212	0.0044	0.0193	0.0040	0.0177	0.0037
3/0	0.0138	0.0042	0.0125	0.0038	0.0115	0.0035
350kcmil	0.0065	0.0040	0.0059	0.0036	0.0054	0.0033
500kcmil	0.0046	0.0039	0.0042	0.0035	0.0038	0.0032
1000kcmil	0.0024	0.0037	0.0022	0.0034	0.0020	0.0031

CABLE TYPE	CONDUCTOR RADIUS (IN)	INSULATION THICKNESS (IN)
#2	0.1460	0.0600
1/0	0.1865	0.0800
3/0	0.2350	0.0800
350kcmil	0.3405	0.0950
500kcmil	0.4065	0.0950
1000kcmil	0.5760	0.1100

EXPLANATION OF HEADINGS

R – RESISTANCE VALUE

X – REACTANCE VALUE

Notes:

A. All values are in OHMS per 1000 ft. at 90° C

B. Source of the values: National Electrical Code (NEC) 1996.

Indicates Latest Revision | Completely Revised | New Page

REVISION
DATE 1-1-2000
APPD JMC / CMK

SDG&E DISTRIBUTION DESIGN MANUAL

UNDERGROUND 600V CABLE IMPEDANCES

5913.3

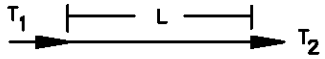
PULLING TENSION CALCULATIONS

THE INTENT OF THE FOLLOWING EQUATIONS IS TO HELP YOU TO DETERMINE TENSIONS FOR A TYPICAL CABLE INSTALLATION. IN ORDER TO USE THESE FORMULAS, THE CABLE PULL SHOULD BE DIVIDED INTO SPECIFIC SECTIONS. PLEASE TAKE NOTE THAT THE TENSION OBTAINED WHEN PULLING IN ONE DIRECTION OFTEN DIFFERS FROM THE TENSION OBTAINED WHEN PULLING IN THE OPPOSITE DIRECTION, THIS IS DUE TO THE SLOPE OF THE PULL AND THE LOCATION OF THE BENDS.

STRAIGHT SECTIONS

CASE 1: HORIZONTAL

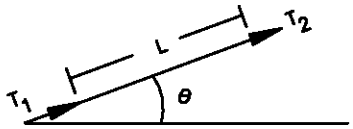
$T_2 = T_1 + L\ W\ C$



CASE 2: INCLINE UPWARD

$T_2 = T_1 + L\ W\ [\ SIN\ \theta + C\ COS\ \theta\ ]$

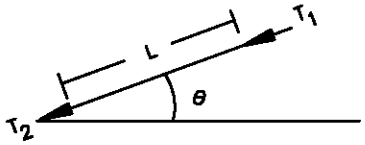
NOTE: ANGLE θ (IN DEGREES) MEASURED FROM THE HORIZONTAL AXIS.



CASE 3: INCLINE DOWNWARD

$T_2 = T_1 - L\ W\ [\ SIN\ \theta - C\ COS\ \theta\ ]$

NOTE: ANGLE θ (IN DEGREES) MEASURED FROM THE HORIZONTAL AXIS.

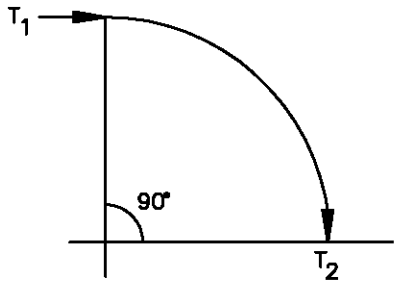


CURVE SECTIONS

$T_{OUT} = T_{IN}\ K$, WHERE THE VALUE OF K (THE CURVE CONSTANT) IS DETERMINED BY

THE ANGLE, IN DEGREES, OF THE CURVE SECTION.

E.G. $T_2 = T_1\ K$



LEGEND

Tx	PULLING TENSION AT A POINT 'X'. (T_1 = TENSION AT POINT NUMBER 1)
Lx	LENGTH OF STRAIGHT SECTION 'X'. (L_1 = LENGTH OF STRAIGHT SECTION NUMBER 1)
W	WEIGHT OF CABLE IN LBS PER FOOT (LBS/FT). UGS 4003.1 LISTS CABLE WEIGHT IN LBS/1000 FT TO FIND LBS/FT DIVIDE BY 1000, E.G. W (1/C #2 SOL XLPECN-PEJ AL) = $\frac{440}{1000}$ = .44 (LBS/FT)
C	.70 (COEFFICIENT OF FRICTION)
θ	GREEK ALPHABET LETTER USED TO IDENTIFY OR NAME AN ANGLE. PRONOUNCED 'THETA'.
K	CURVE CONSTANT.
SIN	ABBREVIATION FOR SINE, A TRIGONOMETRY RATIO RELATED TO ANGLES. (SIN θ = SINE OF THE ANGLE THETA)
COS	ABBREVIATION FOR COSINE, A TRIGONOMETRY RATIO RELATED TO ANGLES. (COS θ = COSINE OF THE ANGLE THETA)

CURVE CONSTANTS TABLE

ANGLE IN DEGREES	K VALUE
11.25°	1.05
22.5°	1.10
33.75°	1.16
45°	1.22
56.25°	1.28
67.5°	1.34
78.75°	1.41
90°	1.48

TRIGONOMETRY TABLE

ANGLE θ	SIN θ	COS θ
2°	.035	.999
3°	.052	.999
4°	.070	.998
5°	.087	.996
6°	.105	.995
7°	.129	.993
8°	.139	.990
9°	.156	.988
10°	.174	.985
11°	.191	.982
12°	.208	.978
13°	.225	.974
14°	.242	.970
15°	.259	.966

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THE ABOVE FORMULAS MAKE FOR FAST AND CONVENIENT MANUAL PULLING TENSION CALCULATIONS. THE COMPLETE PULLING TENSION EQUATIONS ARE MORE COMPLEX THAN THOSE PRESENTED ABOVE AND ARE INCORPORATED INTO THE INTELLICAD PROGRAM. IF MORE PRECISE CALCULATIONS ARE REQUIRED USE THE INTELLICAD INTELLICAD PROGRAM. OTHERWISE, THE MANUAL CALCULATIONS PROVIDE AN EQUIVALENT APPROXIMATION.

ASSUME INITIAL TENSION TO BE 50 LBS (REEL TENSION) AT THE BEGINNING OF ALL PULLS
....BOTTOM OF FIRST ELBOW OF PADMOUNT EQUIPMENT
....FEED–IN POINT OF SUBSTRUCTURES

ALL CALCULATIONS USE VALUE OF .70 FOR COEFFICIENT OF FRICTION, REGARDLESS OF TYPE OF CONDUIT.

CABLE PULLING TENSION:
THE FORCE REQUIRED (IN POUNDS) TO PULL A CABLE THROUGH A CONDUIT. MAXIMUM CABLE TENSIONS HAVE BEEN SET TO PROTECT THE CABLE AND CONDUIT FROM DAMAGE DUE TO EXCESSIVE PULLING FORCE. UNDERGROUND STANDARD 4003.1 LISTS MAXIMUM PULLING TENSIONS ALLOWABLE FOR BOTH PRIMARY AND SECONDARY CABLE.

SIDEWALL BEARING PRESSURE (SWBP):
SWBP IS THE PRESSURE EXERTED BY THE CABLE ON THE SIDEWALL OF THE CONDUIT WHEN GOING THROUGH A BEND. SWBP IS CALCULATED USING THE CABLE TENSION AT THE BEND EXIT, DIVIDED BY THE RADIUS OF CURVATURE OF THE BEND (MEASURED IN FEET). UNDERGROUND STANDARD 3373.2 LISTS RADIUS OF CURVATURE, EITHER IN FEET OR INCHES, FOR INDIVIDUAL CONDUITS.

MAXIMUM ALLOWABLE SWBP:	
CONCRETE ENCASED CONDUITS, JACKETED CABLE	1250 LBS/FT
CONCRETE ENCASED CONDUITS, UN–JACKETED CABLE	750 LBS/FT
DIRECT BURIED CONDUITS	300 LBS/FT

INSTALLATION:

1. DO NOT EXCEED MAXIMUM PULLING TENSIONS ALLOWABLE, FOR PULLING GRIP OR EYE.
2. TO OBTAIN LOWEST TENSION, USE AS FEW CURVED SECTIONS AS POSSIBLE AND MAXIMUM POSSIBLE RADIUS OF CURVATURE.
3. DO NOT EXCEED MAXIMUM ALLOWABLE SWBP FOR APPROPRIATE CONDUIT AND CABLE TYPE.
4. PULLING TENSIONS SHALL BE CALCULATED FOR PULLING FROM EACH DIRECTION. WHEN ALLOWABLE PULLING LIMITS ARE MET PULLING IN ONE DIRECTION ONLY, THE CUSTOMER PROJECT PLANNER SHALL SPECIFY THE PREFERRED DIRECTION OF PULL ON THE JOB SKETCH AND IN THE DBL LOCATION NOTES .
5. CABLE IS ALWAYS PULLED AT THE CABLE POLE. CALCULATE CABLE POLE PULLS FOR ONE DIRECTION ONLY – FEEDING TOWARD THE CABLE POLE.

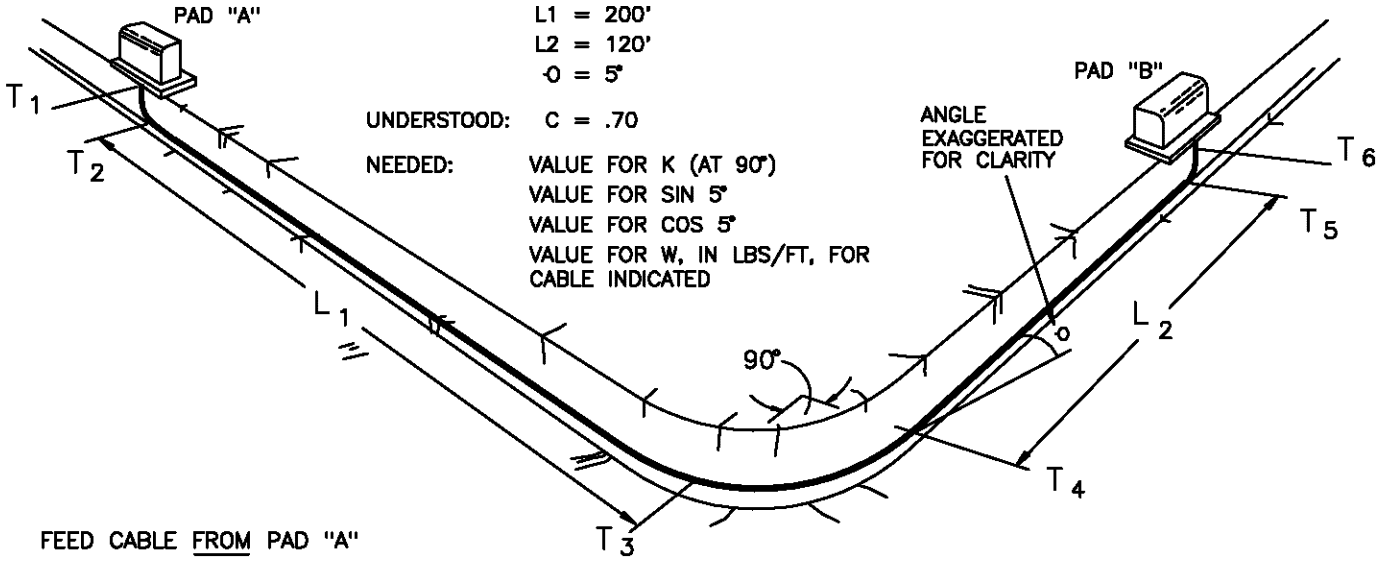
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SAMPLE CALCULATION TO DETERMINE PULLING TENSION AND DIRECTION OF FEED

GIVEN: 1/C #2 SOL AL (XPLECN–PEJ) CABLE
1DB2" CONDUIT
90° = ANGULAR CHANGE IN DIRECTION BETWEEN T3 & T4
L1 = 200'
L2 = 120'
O = 5°

UNDERSTOOD: C = .70

NEEDED: VALUE FOR K (AT 90°)
VALUE FOR SIN 5°
VALUE FOR COS 5°
VALUE FOR W, IN LBS/FT, FOR CABLE INDICATED



FEED CABLE FROM PAD "A"

T_2 = 50, ASSUMES 50 LBS REEL TENSION

$T_3 = T_2 + L_1\ W\ C = 50 + (200 \times .44 \times .70)$
$= 50 + 61.6$
$T3 = 111.6$

$T_4 = T_3\ K$ (FOR 90°) = 111.6 X 1.48 = 165.17

$T_5 = T_4 + L_2\ W\ [\ SIN\ O + C\ \ COS\ O] = 165.17 + (120 \times .44\ [\ .087 + (.70 \times .996)])$
$= 165.17 + (\ 52.8\ [\ .087 + .697\ ])$
$= 165.17 + (\ 52.8\ [\ .784\ ])$
$= 165.17 + (\ 52.8\ X\ .784\ )$
$= 165.17 + 41.39$
$T5 = 206.6$

$T_6 = T_5\ K$ (FOR 90°) = 206.6 X 1.48 = 305.7

$T_{TOTAL} = T_6$ = 306 LBS

FEED CABLE FROM PAD "B"

T_5 = 50, ASSUMES 50 LBS REEL TENSION

$T_4 = T_5 - L_2\ W\ [\ SIN\ O - C\ \ COS\ O] = 50 - (\ 120 \times .44\ [\ .087 - (.70 \times .996)])$
$= 50 - (\ 52.8\ [\ .087 - (\ .697\ ])$
$= 50 - (\ 52.8\ [\ -.610\ ])$
$= 50 - (\ 52.8\ X\ -.610\ )$
$= 50 - (\ -32.208\ )$
$= 50 + 32.208$
$T_4 = 82.208 = 82.21$

$T_3 = T_4\ K = 82.21 \times 1.48 = 121.67$

$T_2 = T_3 + L_1\ W\ C = 121.67 + (200 \times .44 \times .70)$
$= 121.67 + 61.6$
$T_2 = 183.27$

$T_1 = T_2\ K = 183.27 \times 1.48 = 271.2$

$T_{TOTAL} = T_1$ = 271 LBS

RESULTS: TENSION IS WITHIN ACCEPTABLE LIMITS USING PULLING GRIP (OR EYE)AND PULLING FROM EITHER DIRECTION. SWBP AT ELBOWS IS ALSO WITHIN ACCEPTABLE LIMITS FOR DB2" CONDUIT.

CONCLUSION: OKAY TO MAKE THE PULL. SINCE TENSION PULLING FROM PAD "B" IS LOWER, THAT IS THE PREFERRED DIRECTION OF PULL.

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SCOPE:

This standard establishes the cable tail length required to locate and terminate underground cable in equipment or on cable poles.

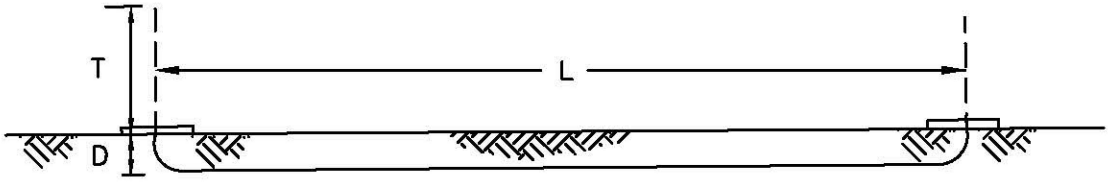
PURPOSE

The purpose of this standard is to provide the necessary additional cable footage (Cable Tail Length) to the total cable requirements.

DEFINITIONS

Lateral Distance – the horizontal separation (L) between points of cable entry into underground equipment. This is normally represented as the trench length between adjacent pieces of equipment.

Cable Tail Length – the additional cable footage required beyond the lateral distance to allow for the trench depth (D) and cable termination (T).



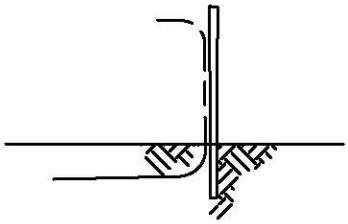
APPLICATION:

The following illustrations show standard cable tail lengths for a variety of design configurations.

A. Cables Poles

For primary cable
For secondary cable

Illustrations

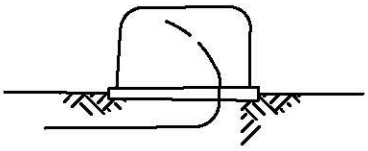


Cable Tail Lengths

Calculation of cable tail lengths for cable poles is based on the measurement from the ground line to the top of the conduit plus 8 feet of cable.

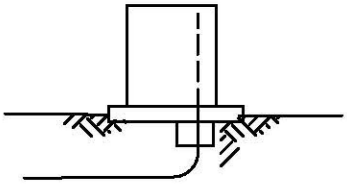
B. Pad Mounts

Single–phase terminator (3522)



6 feet

Service Restorer (3575)



10 feet

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	Indicates Latest Revision	Completely Revised	New Page	Information Removed

REVISION DATE 8–26–08 APPD JE / MC	SDG&E DISTRIBUTION DESIGN MANUAL CABLE TAIL LENGTH REQUIREMENTS	5922.1

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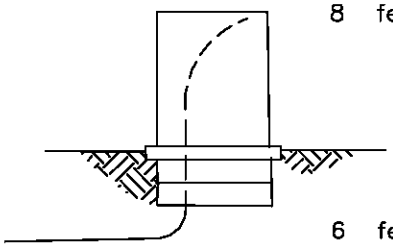
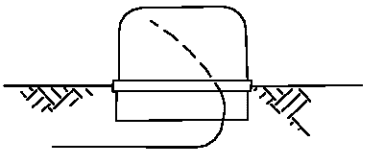
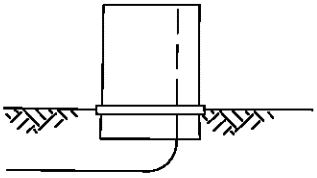
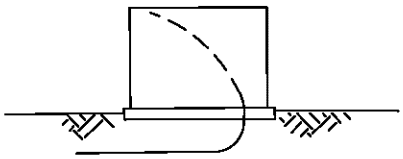
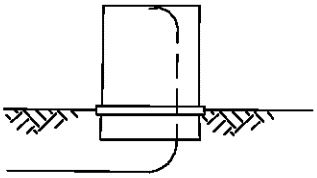
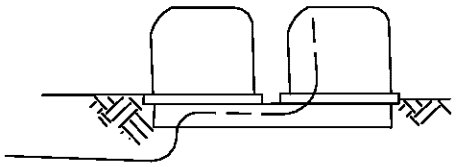
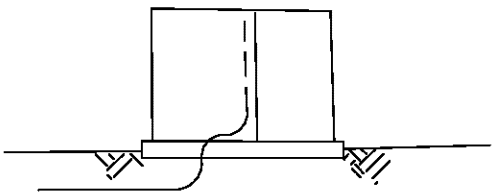
	Illustrations	Cable Tail Lengths
With three–phase terminator, existing (3520 or 3521)		8 feet
With single–phase fuse cabinet (3512)		6 feet
With three–phase fuse cabinet (3513)		8 feet
With single–phase livefront or deadfront transformer (3711 or 3712)		6 feet
With single–phase livefront or deadfront transformer with handhole		7 feet
With single–phase deadfront, open delta transformer with handhole		11 feet
With three–phase deadfront transformer		7 feet

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5922.2	SDG&E DISTRIBUTION DESIGN MANUAL CABLE TAIL LENGTH REQUIREMENTS	REVISION DATE 3–30–84 APPD CVN

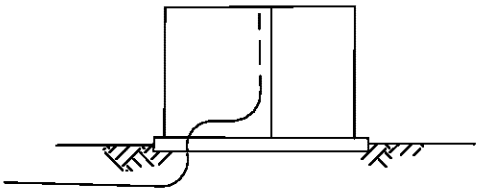
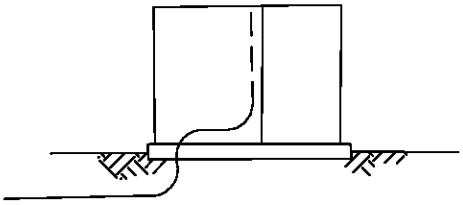
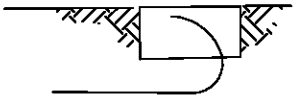
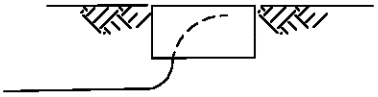
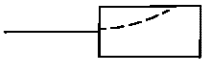
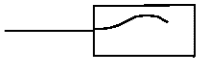
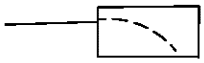
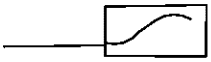
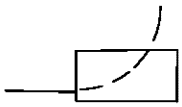
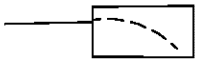
	Illustrations	Cable Tail Lengths
With three–phase livefront transformer (225 to 1000 kVA)		10 feet
With three–phase livefront transformer (1500 to 2500 kVA)		13 feet
C. Handholes		
3312		6 feet
3313		7 feet
3314		8 feet
3314 With cable taps		9 feet
3315		8 feet
3315 With cable taps		10 feet
3315 or 3316 With pad–mounted switch		13 feet
3316		13 feet

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REVISION DATE 1–1–94 APPD MF/RDS	SDG&E DISTRIBUTION DESIGN MANUAL			
	CABLE TAIL LENGTH REQUIREMENTS			5922.3

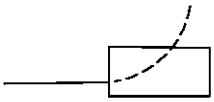
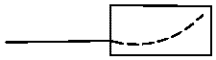
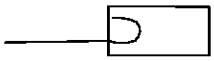
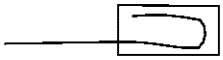
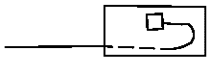
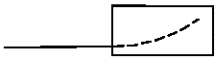
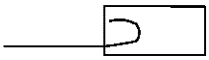
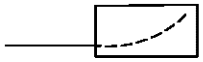
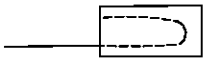
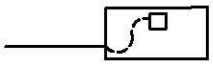
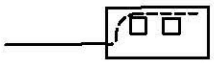
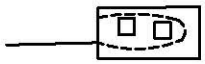
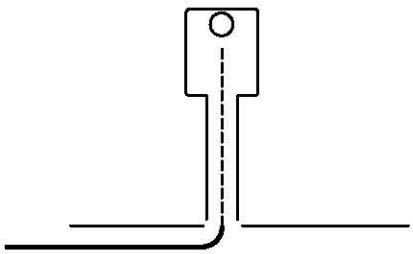
	Illustrations	Cable Tail Lengths
3316 With cable taps		16 feet
D. Manholes		
3320 w/PMH 9 or PMH 11 Switch		16 feet
3322		11 feet
3322 For #2/0 & below		8 feet
3322 For 350 kcmil & above		30 feet
3322 With switch (existing)		12 feet
3322 With switch (existing)		19 feet
3324 – 14'		16 feet
3324 – 14' For 2/0 & below		10 feet
3324 – 20'		22 feet
3324 – 20' for 350 kcmil & above		50 feet

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5922.4	SDG&E DISTRIBUTION DESIGN MANUAL CABLE TAIL LENGTH REQUIREMENTS	REVISION DATE 3-30-84 APPD MF/RDG

	Illustrations	Cable Tail Lengths
3324 – 14' With one switch		16 feet
3324 – 14' With one switch		19 feet
3324 – 20' With one switch (existing)		22 feet
3324 – 20' With one switch (existing)		40 feet
3324 – 26' With two switches		40 feet
3324 – 26' With two switches		65 feet
E. METER PANELS		10 feet

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SCOPE:

This standard establishes preferred cable installation practices, and shall be used by all designers/planners when designing underground jobs.

A. General Primary Conductor Application
Cable size is to be determined based on expected loading and Design Standard 6241.

1. Single–phase branches extending from a three–phase system should use 1/C #2 aluminum cable.

2. Three–phase loads should use 3–1/C–#2 or 3–1/C–#2/0 aluminum cable as required for ampacity. Refer to Design Standard 6241 for optimum design loading.

3. 350 kcmil, TRXLPECN–PEJ, 3–1/C aluminum cable can be used as a feeder cable where the largest available conduit is 4" and projected load will not reguire the use of 750 compact cable.

4. 1000 kcmil, TRXLPECN–PEJ, 3–1/C aluminum cable should be used as feeder cable when 5" conduit is available except in the substation getaway.

5. 1000 kcmil, TRXLPECN–PEJ, 3–1/C copper cable should be used in the substation getaway to the first substructure or cable pole outside the substation fence when 5" conduit is available.

6. 750 kcmil, EPR–PEJ, compact aluminum and copper cable is available for use as replacement for PILC cable and for a substation getaway or feeder extension where the largest conduit available is 4".

7. For areas where existing PILC circuits are to be extended, splicing kits are available to transition from PILC to PECN. These transition kits must be ordered for each job. See Underground Construction tion Standard 4147. If space is available in the substructure the Patton and Cooke junction grounding bar should be installed. See Underground Construction standard 4183.

B. Special Use of 3–1/C – #2/0 Aluminum Cable

There are some cases when the load to be served is too large for a single fusing device, but not large enough to need cable larger than 2/0 aluminum. In those cases 2/0 cable may be used subject to the following criteria:

1. All looping criteria must be met. This includes both feeder and local distribution (See Design Standard 5221.)

2. The 2/0 cable is the most economical cable to use as determined according to Design Standard 6241.

3. The area to be served by 2/0 cable is "enclosed", i.e., no future development is possible, except as allowed in (4) below.

4. In some cases 2/0 cable may be used to delay the installation of more expensive larger cable. This may be done if the larger cable is not needed for at least ten (10) years.

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6000
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SUBSTATION
LOAD FORCASTING

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The design standards pertaining to Load Forecasting are being revised, and have temporarily been removed from the Design Manual. Please contact Distribution Planning for the latest procedures describing substation or circuit load forecasting. The design standards being revised are: 6021, 6022, 6023, and 6024.

6100
SECTIONALIZING
& PROTECTION

6100
SECTIONALIZING
& PROTECTION

PAGE	SUBJECT
6111	FEEDER CIRCUIT SECTIONALIZING AND PROTECTION
6112	RECLOSER APPLICATION CRITERIA
6113	FAULT INDICATORS
6115	DESIGN CHECKLIST FOR SCADA JOBS
6121	FUSE APPLICATION CRITERIA
6131	UNDERGROUND TRANSFORMER/FUSE COORDINATION TABLES
6132	CURRENT-LIMITING PROTECTING FUSE COORDINATION TABLES
6133	FUSE COORDINATION TABLES
6142	SECONDARY FAULT CURRENT CALCULATIONS
6144	DISTRIBUTION CIRCUIT PROTECTION ANALYSIS
6145	DISTRIBUTION CIRCUIT RELIABILITY ANALYSIS

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D	EDITORIAL CHANGES	EPC	JA	FRC	CZH	08/26/2021	G	6134 AND 6136 MOVED TO FMO	YZZ	MOV	FRC	FRC	07/14/2026
C	EDITORIAL CHANGES	JAS	JAS	FRC	CZH	01/22/2021	F	EDITORIAL CHANGES	JIK	YZZ	-	-	04/25/2025
B	FORMATTING				JAS	12/02/2020	E	6114 MOVED TO FMO	JIK	MAK	FRC	KRG	09/16/2024

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SCOPE:

This design standard provides criteria for the placement of overhead and underground switches on 12kV feeder circuits.

PURPOSE:

The switch application criteria was established to maintain distribution system reliability and to facilitate construction operations during maintenance, new business activities, and restoration of service activities. There is no such thing as a typical circuit so this criteria represents the ultimate concept of what the switch configuration should look like when the system is mature. For SCADA switch installations the overall plan is to separate a circuit into 4-5 switching segments (approximately every 100 amps of actual load) plus have tie switches available to support the faulted circuits.

DEFINITIONS:

Overhead Feeder – the term used for the 600 A primary overhead system incorporating J/0 ACSR and larger conductors.

Underground Feeder – the term used for the 600 A primary underground cable system where 350, 750 and 1000 KCMIL AL or 4/0 and 500 KCMIL CU primary cable is used.

Major Critical Customer – the term used for those customers exceeding 1000 kVA 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 included.

Feeder Cable Pole – a pole used to convert overhead to underground where 350, 750 and 1000 KCMIL AL or 4/0 and 500 KCMIL CU underground cable is attached.

Feeder Line Segment – the feeder conductor that exists between adjacent sectionalizing switches.

Demand Factor – the ratio of actual load to transformer connected kVA. It is estimated to be 50 percent system wide for loads on the feeder system.

CRITERIA

Switch placement is determined by circuit configuration as defined below.

A. Feeder Circuit Criteria

1. Based on the division of the average 12 kV feeder circuit into line segments, the following placement of switches results.

   a. No more than one mile of overhead or underground feeder should exist between switches.

   b. An overhead or underground switch should be placed every 100 A of actual 12 kV peak load or 4000 kVA of connected line transformer nameplate load, whichever comes first. This means that 4000 kVA is maximum amount of load that can be connected directly to a feeder line segment.

   c. No more than 1000 metered customers shall be connected between switches.

   d. Load connected to the feeder line segment past a switch position should be used to meet the criteria in 1.b.

2. PME style switchgear shall be used for new underground switch installations, unless the PME style is determined not to be feasible due to lack of space or easement turndown. Easements shall be acquired when necessary to accommodate the PME switchgear.

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A	ORIGINAL ISSUE				JCE	03/01/2002	D						

3. All branch circuit connections to the underground feeder systems shall be made through fuses or 600 A switch positions.

   a. All transformers 2500 kVA or less shall be connected to the feeder system through appropriate fusing, except as noted in 3d.

   b. PME style switchgear shall be used to fuse 1500, 2000, and 2500 kVA transformers, except as noted in 3c and 3d

   c. An existing 600 A vacant switch position may be used with a fuse cabinet to connect a single 1500 or 2000 kVA transformer, subject to sectionalizing and load criteria described in 1. Contact the appropriate Distribution Planning engineer for approval to use any vacant switch position.

   d. An existing 600 A vacant switch position may be used without fusing to connect a single 2500 kVA transformer, subject to sectionalizing and load criteria described in 1. Contact the appropriate Distribution Planning engineer for approval to use any vacant switch position.

   e. A dedicated switch position shall be used for all 3000 kVA transformer connections. Contact the appropriate Distribution Planning engineer for approval to use an existing 600 A vacant switch position if it is being considered to serve this transformer.

   f. All primary metered service connections to the feeder system shall be made through fuses, switches, or switch positions capable of fault interruption. They are exempt from the requirements in A1b of this section. Current Limiting Fuses should not be used, as they will generally not coordinate well with the customer's equipment, and may result in more extended outages for the primary customer.

4. In cases where a maximum transformer capacity of 1500 kVA is being connected, and no feeder sectionalizing is required, now or in the future, a fuse cabinet may be used if reviewed and approved by Distribution Planning. In cases where transformer capacity greater than 1500 kVA and/or feeder sectionalizing is anticipated in the future, easements shall be acquired for future PME switchgear at or near the fuse cabinet position. For 4000 A main panels obtain easements for the 3423 box pad regardless of initial calculated demand.

The connections discussed in items 3a-3e and 4 are summarized in Table 1 below.

TABLE 1

Transformer Size	PME with Fuse Compartment	PME Switch	Fuse Cabinet Connected to Vacant Switch Position (Requires Distribution Planning Approval) See Item 3c	Fuse Cabinet Connected to Feeder Line Segment (Requires Distribution Planning Approval) See Item 4	Vacant Switch Position (Requires Distribution Planning Approval) See Item 3d & 3e
1500 kVA	X		X	X	
2000 kVA	X		X		
2500 kVA	X				X
3000 kVA		X			X

5. Exceptions to the above may be warranted based on existing system conditions. This could include not fusing a single transformer if it is being served by not more than 30 feet of local distribution cable and a suitable fused elbow location is not within 120 feet of the transformer. These exceptions shall be reviewed and approved by the Design Standards engineer in Distribution Standards.

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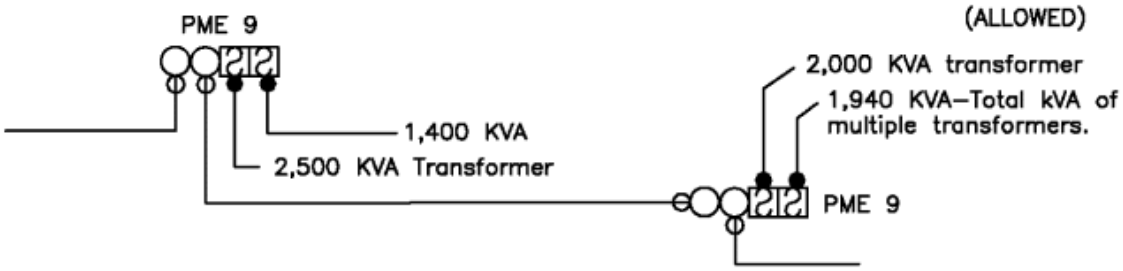
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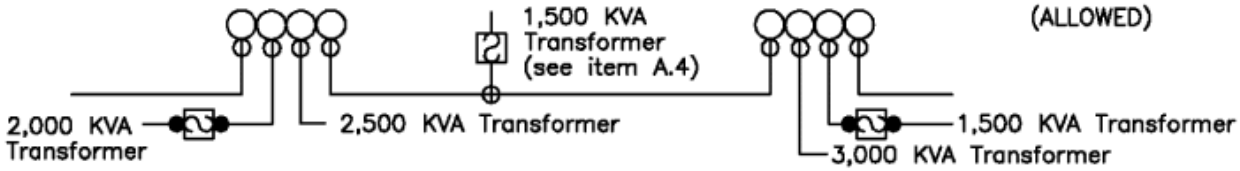
EXAMPLES





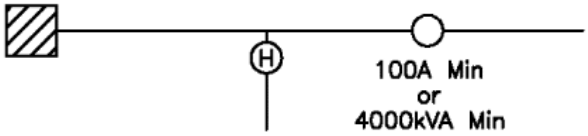


EXISTING SWITCH WITH VACANT SWITCH POSITION(S)



6. To provide for future extension of the distribution feeder without the necessity of a long prearranged outage and to allow service restoration of the feeder as promptly as possible, a switch should be placed on each load side feeder line segment as shown below provided at least 100 A of actual load or 4000 kVA of connected load exists on the line segment. If the minimum requirements are not met, switch placement is dependent on condition A.1. above.

   a. Overhead Feeder Split Line
   The switch placement for a source side feeder line segment serving two loads is illustrated below



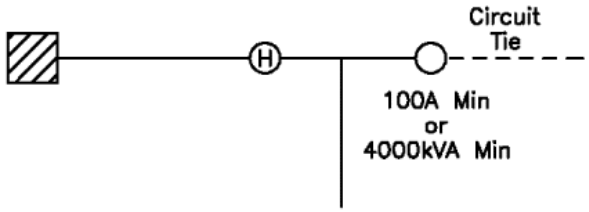
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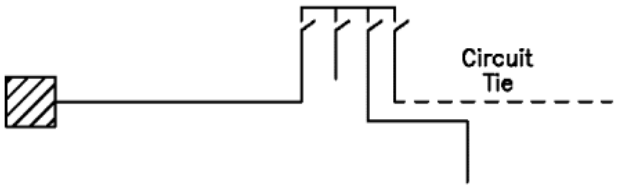
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If one of the switches is used as a circuit tie, it should be gang-operated, and the other switch should be located on the source side feeder line segment as shown in the following diagram. This will allow greater flexibility during load restoration.

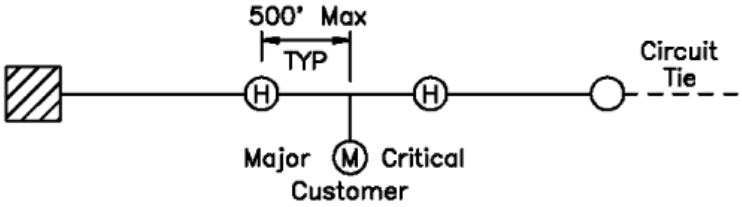


b. Underground Feeder Line Split
The underground switch provides a switch position on each feeder line segment as shown below, therefore, differentiation is not needed when one line segment is a circuit tie.



B. Major Critical Customer Criteria

1. To provide maximum operating flexibility, the feeder line segments surrounding a major critical customer shall be sectionalized as shown in the following diagram. This permits service restoration of the major critical customer through a tie switch to an adjacent circuit.



C. Future Feeder Switch Criteria

1. Overhead

   A switch should be installed as needed to satisfy the Feeder Circuit Criteria (A.1 and A.6).

2. Underground

   A switch should be installed as needed to satisfy the Feeder Circuit Criteria (A.1 and A.6) provided that delayed installation of the switch to a future date will not result in excessive customer outage due to feeder system interruption. If future installation of the switch would result in excessive customer outage, it should be provided for while the rest of the underground system is being installed in the area. Reasonable judgment should be used when deciding how far in advance a switch should be installed. Generally, switch installation is warranted if need is anticipated within two years. Otherwise, o substructure should initially be installed to provide for cable training to a future padmounted switch.

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D. Future Feeder Switch Criteria

A switch should be installed on each feeder cable pole to provide isolation of the underground system from the overhead system unless:

1. A padmounted switch is in close proximity to the pole with no load tapped and no possibility of load being tapped between the cable pole and the switch.

2. On overhead switch, with truck access, is in close proximity with no load tapped and no possibility of load being tapped between the switch and the underground tie-in/connection point.

E. Geographic Criteria

A line switch should be installed:

1. At on accessible location (one near a roadway), and

2. At each end of a feeder line segment that traverses an inaccessible area which is susceptible to damage and difficult to patrol. This will allow isolation of on area that requires a longer than average patrol.

F. Switch Selection Criteria

1. Overhead

   a. Use 3-Ø gang-operated switches at the following locations:

      1) Tie switches

      2) Where line switches are required under the Feeder Circuit Criteria (page 6111.1, A.1) such that there is a gang-operated switch at least every one mile or 100 A of load, but not more often than every ½ mile or 50 A of load.

      3) Where pole climbing limitations would extend the time required for switching, (e.g., 4kV underbuild).

   b. Hookstick switches are to be installed at all other 4kV and 12kV switch application locations.

   c. FO-11 Oil Switches in the 4 kV System:

      When they are removed for maintenance, one of the following steps shall be taken:

      1) If sectionalizing is still required, replace the F0-11, 4kV oil switch with a 600 ampere, air insulated 14.4kV disconnect (M&S 707008) without regard for proximity to the coast.

      2) If sectionalizing is no longer required, remove the FO-11 switch and jumper out deadends.

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2. Underground

Padmounted switches should be installed in accordance with Design Manual Standard 5240 (Underground System Equipment Selection and Location) and 5236 (Sight Distance Requirement) and 5250 (UG Sectionalizing Equipment Application).

a. The following arrangement shall be used for making circuit ties involving underground circuits:

Overhead to Underground: The underground connection shall be:

1) From a padmounted switch to a cable pole with 600 A hook stick switches, or

2) From 3-way 600 A Tees, a 3-Ø terminator, or a subsurface switch to a coble pole with a gang-operated switch.

Underground to Underground:

1) The preferred connection shall be from 3-way 600 Amp Tees to a subsurface or padmounted switch. The intent here is to avoid using two 600 A, 4-woy switches for the sole purpose of making a circuit tie.

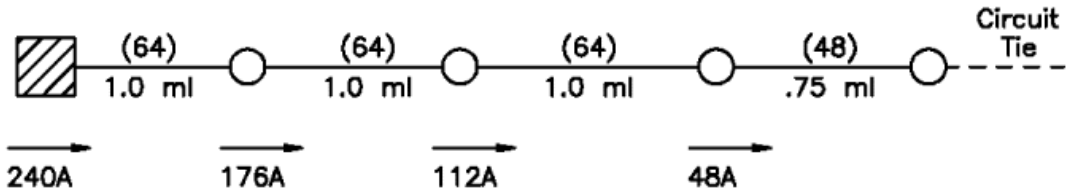
2) The tie may be mode between two 600 A switches if both switches are needed for other reasons.

3. Examples

A new 12 kV circuit is to be built. It will have 240 A of uniformly distributed actual load along its 3.75 mile feeder. Determine the switch locations.

a. Determine the load at one mile increments along the feeder:
240 A ÷ 3.75 mi = 64 A per mile

b. Based on the Feeder Circuit Criteria (A.1), switches should be installed every mile along the feeder because each mile feeder line segment serves more than 50 A, but less than 100 A of load.



Notes:
1) All switches shall be gang-operated because they are required under the Feeder Circuit Criteria (page 6111. 1, A 1)

2) (64) denotes 64 A of actual load on feeder line segment.

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G. SCADA Switches Criteria

1. This criteria represents the ultimate concept of what the switch configuration should look like when the system is built out. Switches installed at strategic points on the circuit using the criteria shown in A.1 through C.2 (breaking the circuit into 4 to 5 switching segments or at key tie points) should normally be SCADA switches if the following applies:

   a. At strategic points on a circuit such as major intersections or circuit branching points, where the circuit bifurcates, or trifurcates, or

   b. Is at a strategic location and is required to help provide an adequate number of SCADA tie switches to fully support faulted circuits. SCADA tie switches should be located such that at least 40% of customers on the feeder should be connected between the point of tie connection and the substation circuit breaker. The Distribution Planning engineer should consider future circuit configuration changes when deciding whether to put in a SCADA tie switch.

   c. At least 40% of the customers on a feeder shall be located between the substation circuit breaker and the first SCADA switch.

   d. If it is a circuit with a high SAIDI index, recent reliability records should be consulted for this information. Use the last five years' history.

   e. Other factors equal, SCADA ties between circuits originating form different substations are preferred.

   f. Switches not at key sectionalizing or tie points as specified above, will not be SCADA switches unless other requirements make it necessary (i.e. Major Customer as defined on DM 6111.1, and Special Commercial Customers as defined on DM 6145.1, etc.)

2. All new, as well as replacement switches being installed, should be evaluated against this criteria whether:

   a. Installing switches on new business projects, regardless of the type of customers (commercial, industrial, residential), or

   b. Installing switches on new feeder and circuit extension projects, or

   c. Overhead to underground conversions, or

   d. When replacing existing switches on maintenance, switches in strategic locations should be SCADA, or

   e. For reliability projects
   Projects are always prioritized using contemporary methods to provide a ranking. The aggregate value of reliability projects almost always exceeds what the approved capital budget allocations can support in a given calendar.

3. A request to install a SCADA switches should be submitted on a Distribution Planning Worksheet for the planning engineer's approval. The planning engineer needs to take into account the long-range configuration for the circuit when specifying SCADA switch locations. Some smaller circuits from a SCADA substation may be too small (in customer count, length and/or MW) to require SCADA switches. The planning engineer is responsible to determine if a SCADA switch is required.

4. Design manual pages 6115.1 & .2 provides a check list for installing SCADA switches.

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B	CRITERIA G.1 AND G.2				JAS	12/02/2020	E						
A	ORIGINAL ISSUE				DRM	01/01/2000	D						

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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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.

SCOPE

This design standard provides criteria for the placement of permanent and temporarily installed automatic self-resetting fault indicators (FI) on the overhead and underground distribution systems. In addition, this design standard establishes criteria to provide Qualified Electrical Workers (QEW) a visual indication of a faulted feeder or branch segment using FI. Table 1 summarizes the different FI's available with the recommended application when designing a job or used in the field.

DEFINITIONS

- FI – Fault Indicator or Fault Circuit Indicator indicates a fault when a minimum trip value setting is reached, see Table 1. Fault indicators are a single-phase component and installed one per phase.
    - Life expectancy for FIs is typically 20 years, if an FI malfunctions, please replace and return the FI to EDE.
- Automatic Self-Resetting Fault Indicator – A per-phase device that will visually indicate when fault current exceeds the minimum trip setting, resulting from a downstream fault. The current FI will automatically return to normal (reset) when the load current has been restored for a minimum of 60 seconds. See the reset column in Table 1 for additional information.
- Minimum Trip Value – the minimum amount of fault current required to cause the FI to operate.
- HFTD – High Fire Threat District consisting of both Tier 2 and Tier 3:
    - Tier 2 consists of areas on the California Public Utilities Commission's Fire-Threat Map ("CPUC Fire-Threat Map") where there is an elevated risk for destructive utility-associated wildfires.
    - Tier 3 consists of areas on the CPUC Fire-Threat Map where there is an extreme risk for destructive utility-associated wildfires.
- UG Cable Sizes**:**
    - Feeder cable 350 kcmil and above.
    - Branch cable sizes is below 4/0 AL.
- OH Conductor Sizes:
    - Feeder conductor sizes is 336.4 ACSR and above.
    - Branch conductor sizes is below 3/0 ACSR.

CRITERIA

A. All FIs shall be identified and pre-digitized during the design process to correctly map them in the GIS and the NMS systems. Phasing identification must be performed prior to installation.

B. If permanent FIs are installed on trouble, contact EDO to correctly map them in the GIS and the NMS systems

C. A Fusing Request is required only for feeder (600A) conductor or cable to verify the fault current and correctly size the FI. A Fusing Request is not required for branch (200A) systems.

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A	Original Issue				MF	01/01/1994	D						

Table 1: UG and OH Fault Indicators Reference Sheet

UG Fault Indicators Options

Fault Indicator	Application	Reset	Conductor	Min Trip Values	Stock #	Reference
Test Point Reset	Fixed Install (Permanent)	Voltage (≥6 kV) for 15 kV and 25 kV rated elbows Voltage (≥7 kV) for 35 kV rated elbows	200A Elbow with test point	450A	S423770	ESP225 SEL-TPR
Crab Series 222	Fixed Install (Permanent)	Automatic after 2 hours	Feeder Cable	800A	S423716	ESP – Pending FCI 222 Type M
UG Current Reset	Fixed Install (Permanent)	Current (>3A)	Feeder Cable	800A	S423762	UG4352 SEL-CR
				1000A	S423760	
Manual Reset	Temporary Install **(Troubleshooting only)**	Manual	Branch Cable	200A	S423744	ESP224 SEL-MR
				450A	S423772	
				800A	S423742	
			Feeder Cable	450A	S423768	
				800A	S423758	
UG Load Tracker	Fixed Install POWER delivery	Time or Manual	Branch Cable	200A at 200 milliseconds	S423718	ESP252 UG4360 FCI Load Tracker
			Feeder Cable		S423714	

OH Fault Indicators Options

Fault Indicator	Application	Reset	Conductor	Min Trip Values	Stock #	Reference
Load Monitoring	4 kV & 12 kV	Current > 3A or 8 hours	Branch or Feeder	100A at 2 milliseconds	S423698	ESP334 OH1277 Navigator LM
Autoranger	Fixed 4 kV & 12 kV	Self-adjusting	Branch or Feeder Conductor	50A-1200A	S423702	ESP322 OH1276 SEL-AR

D. Applications for OH installations

1. Overhead Feeder Circuit Application

a. Load side of manual line switches (hook- or gang-operated).

b. Cable poles on the line side, load side or both.

c. Feeder bifurcation points (load side of the bifurcation).

d. FI shall "NOT" be installed on:

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1) 2.4 kV circuits

2) Service Restorers

3) Fused local distribution branches

e. Note reset requirements in Table 1.

2. Underground Feeder Circuit Application

a. All manual switches. The FIs is to be installed on each switch position, including line side and tie position(s).

1) Existing FIs installed on any switch positions shall not be removed if the line switch position becomes a tie switch position.

b. SCADA switches do not need FI. The SCADA switches are equipped with internal FI and use the controller relay to communicate the status to the control center.

ATTENTION: If a SCADA switch has external FI, REMOVE the FI, and contact EGIS.

c. FI shall be installed on all new CLEER connectors.

d. FI shall be installed on all new 600A and 200A non-SCADA fault interruption devices.

1) Facilitates finding what phase the fault is on.

e. FI shall be installed on all dead front and/or load break terminators.

1) Due to space limitations, FI shall not be installed inside live front terminators

f. Note reset requirements in Table 1.

REFERENCES

I. Electric Standard Practices

II. Electric Distribution Design Manual 6111, Feeder Circuit Sectionalizing and Protection

III. Overhead Construction Standard 1275, Overhead Fault Indicator Installation & Operation

IV. Underground Construction Standard 4352, Automatic Fault Indicator - Self-Resetting, Hot Stick Operable

V. Underground Construction Standard 4360, Load Tracker Faut Indicator

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SCOPE

This design manual section provides guidance for planners, in the form of a checklist, to help ensure that all aspects of SCADA installation are addressed in the appropriate phase of each SCADA job. SCADA jobs differ from traditional distribution work in that much more coordination is required, involving different departments, and in some cases outside organizations. Often, SCADA work targets major customers, making successful, smooth completion more critical.

PURPOSE

The objective of Supervisory Control and Data Acquisition (SCADA) is to improve service reliability with remote switching capability. Being able to remotely switch will help ensure that service is restored to customers as quickly as possible. SDG&E's Distribution Operations Department can isolate faults more quickly and transfer customers to other circuits. SCADA is also a valuable tool for gathering information such as voltage, current, power factor, etc. for Distribution Planning activities.

Definitions

Communications - ability of equipment in the field to exchange data with the SCADA master computer located at Distribution Operations.

Power Source - Most new distribution line SCADA equipment derives control power directly from the 12kV line; there is no need for a separate secondary source. Exceptions to this are 1) Line (load) monitors, and 2) Switches with SCADA control. Contact Distribution Standards for details.

Points List –

- document sent to Distribution Operations describing the format of the data that will flow between the field device and the SCADA master computer. SPACE will provide DNP (Distributed Network Protocol) map settings to EDOT for new equipment.
- Kearny SCADA Crew will submit a points list to SPACE to be completed and confirmed by SPACE then returned to Kearny.

SCADA Number & RTU Address - integers that index the field Remote Terminal Unit (RTU) for entry into the SCADA master computer database.

"Signal Check Request" - Form that planners use to confirm communication arrangements for a site, sent early in the design process to Sempra - Infrastructure Technology (IT). Sempra - IT takes information from the top of the form and completes the bottom half with recommendations on how to best communicate to the site of interest. This step must be completed prior to completion and submittal of the points list. Form available in email format from Distribution Standards. This form is shown on Design Manual page 6115.3.

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Procedure/Checklist

A. **Preliminary Design Phase** - for use in the initial stages of an approved SCADA Job, or for obtaining budgetary estimates of proposed SCADA installations

1. Verify communications requirements with Sempra-IT. Use "Signal Check Request" form.
2. Confirm other job requirements (location of RTU cabinet, available pole space, mounting height).
3. Generate cost estimate for the job.

B. **Design Phase**

1. Complete and submit points list to Distribution Operations Principal Engineer. Obtain SCADA number and RTU address.
2. Finalize facility placement consistent with safety, traffic contact avoidance, and aesthetics.

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3. Verify status of any other construction that must be finished before SCADA work can commence, such as switch change-out, telecommunications cable, radio, or leased line, etc.

4. Verify status of required special permits, i.e., port district, railroad, Caltrans, etc. For SCADA jobs for major customers, confirm target customers are aware of the work to be done, what the completed installation will look like, and the need for pre-arranged outage, if required. Marketing has primary responsibility for customer interface.

   Submit "fuse request" form for all SCADA projects other than line (load) monitors. Cover the following:

   a. Fusing on any PME-9S or PME-11S cabinet.

   b. Fault interrupter programming for any installation using fault interrupting switchgear (downtown San Diego area).

   c. Distribution Workflow & Planning (DW&P) will confirm minimum end-of- line fault current to ensure correct fault indicator operation. SCADA equipment normally uses fault indicators with a trip setting of 1000 Amps. Other values are available on special order. Contact Distribution Standards.

   d. Confirm desired switch positions for autosectionalizing/fault interruption. This includes all load-side or single position switches where at least 5 Amps of three phase load is expected continuously. This is necessary to ensure fault indicators are always armed. Line and tie switch positions are not included. As a general rule, at least 500 kVA of connected stations are required to ensure 5 Amps continuous load on any given switch position. Individual cases may vary from this and can be confirmed once the site has been on-line through SCADA for a month or two. When necessary, this will be examined cooperatively through Distribution Standards and Distribution Operations.

   e. DW&P and SPACE will confirm the need for upstream (line-side) recloser interval changes, if any. A request will be sent to Protection Engineering to implement changes when required.

   f. Make a note on the job of the switch position(s) where the auto- sectionalizing feature is expected to be activated (enabled). Kearny SCADA crews will use this information to help complete final tests and release to operations. Note: the default status for autosectionalizing is not-activated (disabled).

   g. Remember that load transfer jobs or other reconfiguration work may work require changes to autosectionalizing status of individual SCADA switches or SCADA switch positions.

C. **Construction Phase**

1. Manage project for completion on schedule and within budget. Pay special attention to the need for joint meet between different departments, such as C&O crew, Electric Construction and Maintenance (EC&M), and Telecommunications. Overhead Service Restorer installations normally require a joint meet between the district C&O crew and EC&M crew.

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Items to be completed as follows: Items 1, 2, 4, 6 & 7 by Planner/Designer; Item 3 by IT Network Engineering & Operations; Item 8 Planning Engineer; Item 9 System Protection; Items 5 and 10 by Electric Distribution Operations System Services.

1. REQUESTED BY:

(To be completed by Designer/Planner)

Name of Designer/Requester:		Date:	
Telephone No:		E-mail address:	
Project Office:		Mail Location/Contractor:	
Proj Name, DPSS or SAP:			
Switch WO#		Kearny/SAP SCADA WO#	

2. PROPOSED SCADA SITE DATA:

(To be completed by Designer/Planner)

City:		Lat:	
Structure Number		Long:	
Nearest Intersection/Address:			
District:			
Expected Construction Start Date:			
Equipment Type			
Substation:		Circuit	

Planner Notes:

Installing a new SCADA Capacitor-

(To be completed by IT - Network Engineering & Operations)

3. SCADA MASTER RADIO BASE STATION/SUPERVISORY CABLE RECOMMENDATION:

(To be completed by IT - Network Engineering & Operations)

The following information is to be included on the construction work order:

Recommended Master Station or Repeater:		
Recommended Antenna:		
	Type:	
	Orientation:	
	Pole or antenna support height:	

Telecom Notes:

Reviewed by: Ticket #_____

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SCADA Site/RTU #: 551

4. Check the "switch type" in the left hand column below.

- Include the type of switch in Equipment type field (i.e., PME, Vista 422, ISG, Trayer, Recloser, etc.)
- Check Yes or No if Autosectionalizing is be ENABLED or DISABLED for in each compartment of a PME or Vista type switch.
- On Vista, Trayer and ISG switches: check Yes or No for Ways that will have Fault Interrupting (F) ENABLED or DISABLED
- Place the switch numbers in the bottom row according to the construction design.

NOTE: System Protection must review all SCADA switches via Fuse Request (refer to SPM 450 or AD/CD Manual 450)

DEVICE MODEL: Capacitor

☐	*ANEMOMETER*					
☐	*LINE (LOAD) MONITOR*					
☐	*CAPACITOR*					
☐	*RETROFIT SERVICE RESTORER (RECLOSER)*	*SERVICE RESTORER*	*BYPASS SWITCH*			
☐	*SVC RESTORER (F6, IR, MVR SDR)* *SWITCH (F6, IR, MVR, SDR)*	☐ *SERVICE RESTORER* ☐ **SWITCH**	*BYPASS SWITCH*			
☐	*REGULATOR*	*REG 1*	*REG 2*	*REG 3*		
☐	*PME*	*CMPT - 1*	*CMPT - 2*	*CMPT - 3*	*CMPT - 4*	
☐	*Autosectionalizing Enabled*	☐*Y* ☐*N*	☐*Y* ☐*N*	☐*Y* ☐*N*	☐*Y* ☐*N*	
☐	*TRAYER SWITCH*	*WAY 1*	*WAY 2*	*WAY 3*	*WAY 4*	*WAY 5*
	Fault Interrupting Enabled	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*
☐	*ISG*	*WAY 1*	*WAY 2*	*WAY 3*	*WAY 4*	**WAY 5**	**WAY 6**
	Fault Interrupting Enabled	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*
☐	*VISTA*	*WAY 1*	*WAY 2*	*WAY 3*	*WAY 4*	**WAY 5**	**WAY 6**
	Autosectionalizing Enabled	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	*N/A*	*N/A*
	Fault Interrupting Enabled	*N/A*	*N/A*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*	☐*Y*☐*N*
	SWITCH No's →						

NOTE: EACH SWITCH NO. MUST BE PLACED IN THE CORRECT FIELD BY CMPT, WAY, ETC.

7.	**PLANNING ENGINEER CONTACT:**		
		Name	Telephone #

8. REVIEWED: ☐ YES ☐ NO BY:

9. SYSTEM PROTECTION FEASIBILITY REVIEW (Required for all SCADA switches).

☐ N/A ☐ Approved ☐ Disapproved ☐ Pre-approved Reviewer:

10. RTU TYPE: SEL-734

Submit Request, with all supporting documentation to RBrownfield@semprautilities.com, Place "SCADA Telecommunications Coordination & SCADA Site Request in the subject line of the email. Roberta will open the Sempra Help Ticket and forward to Telecommunications

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SCOPE:

This design standard provides criteria for the application of current-limiting and expulsion fuses on 12kV local distribution branches. It Includes guidelines for new and existing locations.

PURPOSE

The underground fuse application criteria was established to provide isolation of the underground system from the overhead and limit the amount of energy let-through to the underground system under faulted conditions. Overhead fuse application was established to provide the most cost effective fuse placement needed to maintain distribution system reliability.

DEFINITIONS

Cascaded Sub-Branch Fuse - The term applied to a protecting sub-branch fuse installed in series with a protected branch fuse.

Current-Limiting Fuse (CLF) - These fuses introduce a relatively high impedance into the circuit when the element melts, thus forcing the current to a relatively low value prior to opening which limits the total fault current.

Electric Troubleshooter (ETS) - First responder to outages on the overhead and underground electric system.

Expulsion Fuse - These fuses do not limit available fault energy nor do they substantially reduce peak let-through currents.

Fault Tamer - New type of overhead current-limiting fuse for overhead sub-branches that does not cause sparks and other material to reach the ground during operation. They are available in 5, 10, 15, and 20 Amp sizes. They can only be used on the 12kV system.

Feeder Tap Location - Refers to the point where the local distribution branch attaches to the feeder.

Fused Circuit Tie - The term for a normally open fused cutout installed between two adjacent circuits.

Fuse Request - A form submitted to Electric Distribution Planning to size and/or locate/relocate new and existing fuses and non adaptive trip fault indicators.

Local Distribution Branch - Refers to a local distribution conductor that is directly connected to the feeder. The local distribution branch includes all sub-branches it serves.

Local Distribution Sub-Branch - Refers to a local distribution conductor that does not connect directly to the feeder, but originates from a local distribution branch. The local distribution sub-branch includes all the sub-branch taps it serves.

Local Distribution Sub-Branch Tap - Refers to a local distribution conductor that does not connect directly to a local distribution branch but originates from a local distribution sub-branch.

Overhead Local Distribution - The term used for the primary overhead system incorporating conductors smaller than 3/0 ACSR or #1 CU.

SMU-20 - New type of overhead expulsion fuse for overhead main line and sub-branches that does not cause sparks and other material to reach the ground. They are available in 25, 30, 40, 50, 65, 80, 100, 125, 150, and 200 amp sizes. They can be used on the 12kV, 4kV, and 2.4 kV systems.

Underground Local Distribution - The term used for the primary underground system incorporating conductors smaller than 350 KCMIL AL or 4/0 CU.

Wireless Fault Indicator (WFI) - An overhead fault indicating device that senses and reports faults (along with load) with the ability to adjust the fault detection trigger point based on steady state load.

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CRITERIA

A. New Fuse Application

1. Fuses shall be installed on circuit branches as close to the feeder as practical. If this cannot be done because of connected kVA or fuse coordination constraints, contact Distribution Planning or Protection Engineering about the use of an electronic sectionalizer.

2. Fuses shall be installed to insure that all "end-of-line" faults that are not sensed by substation relays will be cleared by the fuse according to the margins contained in section B.1.a.

3. Fused devices, (i.e., fused poles, fuse cabinets or fused elbows) shall be accessible to an ETS in all weather. Vehicle access shall be provided to within 100' of the fused device.

4. When fusing the feeder is desirable, in very remote areas, a disconnect switch shall be placed parallel to the fuse (figure 1) to insure that circuit ties are not disabled.

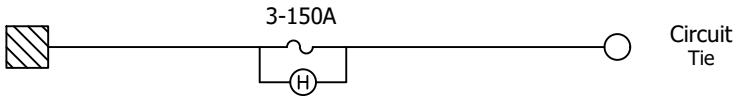


Figure 1 - Fused Feeder

5. Fuses shall be placed around any large inaccessible area such as forests or canyons at the point where the local distribution branch enters and leaves the area.

6. Each local distribution cable pole shall be fused with a CLF provided that:
   a. The load on the fused cable pole is not more than 2080 kVA connected and
      1. The available line-to-ground short circuit current exceeds 1,050 amps.
      2. The fused cable pole does not serve any 12kV overhead line that is unprotected by a QA or Fault Tamer fuse on the up cable pole.
      3. The fused cable pole does not serve a 12kV transformer that is not provided with expulsion fuse protection which coordinates with the CLF such as HDP, HUP, HSV, HGP, WGP, HOP and HHP.
   b. If the above criteria are not met, then the use of a QA or Fault Tamer fuse is required.
   c. If the load served exceeds the capabilities of a single fused cable pole, use a disconnect switch with WFI or FI in its place.

7. Cutouts shall not be installed on a pole:
   a. Where an ETS cannot operate the fuse without climbing through an under-built circuit.
   b. Where climbing space is restricted.

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7. Cutouts shall not be installed on a pole:

   a. Where an ETS cannot operate the fuse without climbing through an under-built circuit.

   b. Where climbing space is restricted.

8. The Fusing Specialist in Electric Distribution Planning shall coordinate all protective devices according to section B or section E of this standard.

9. Each underground local distribution branch shall have fuses applied at the feeder tap location (figure 2) according to table 1 and the following:

   a. Fused elbows are required to be surface operable. The fused elbow must "supply" the cable it serves so that removal of the fused elbow will de-energize the fuse.

   b. Transformers located in vaults shall be protected with 1) CLF(s) installed in wall mounted fuse cabinets, 2) VISTA switches with fault interrupters, or 3) SCADA Trayer switches with fault interrupting enabled.

   c. Fuse cabinets may not be installed:

      1. To serve overhead lines when the up cable pole is not equipped with QA Fault Tamer, or SMU-20 fuses which coordinate with the CLF (see note 2).

      2. On unimproved streets unless they are placed in a permanent location outside of future improvements.

      3. When either fused cable poles or fused elbows may be used (see table 1 for limitations).

   d. Fusing is not required:

      1. On a temporary transformer installation (removal expected within 1 year) that requires the installation of a new fuse cabinet.

      2. On a padmounted capacitor station.

10. Branch fuses shall be installed on the overhead system at the feeder tap location (figure 2) based on the criteria provided in Table 1.

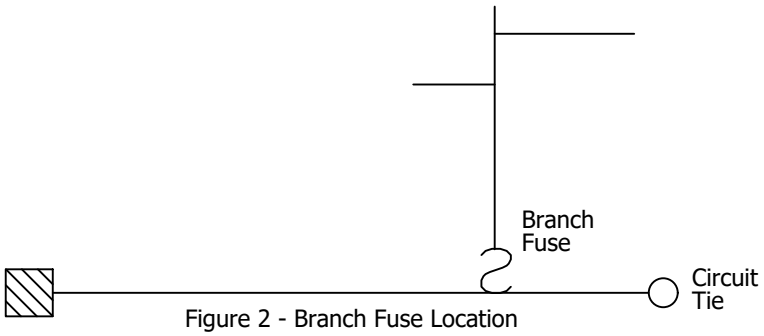


Figure 2 - Branch Fuse Location

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11. Sub-branch fuses shall be installed on overhead or underground branches at the local distribution sub-branch tap (figure 3) based on the criteria provided in table 3.

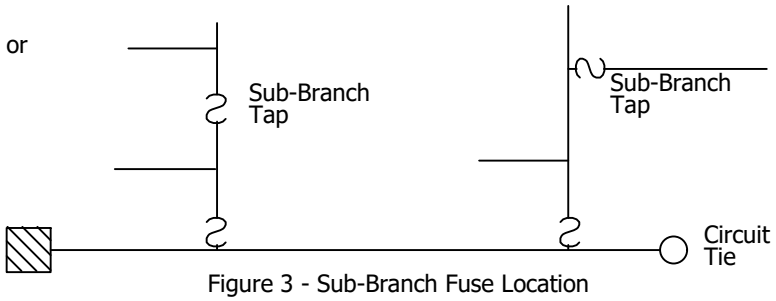


Figure 3 - Sub-Branch Fuse Location

Table 1 - FUSED DEVICE USAGE LIMITS - UNDERGROUND

Device	Usage Limit Based On Fuse
1Ø Fuse Cabinet CLF	0 < connected kVA ≤ 350 kVA, with largest single XFMR 75kVA
1Ø Fused Pole (6.9kV)	0 < connected kVA ≤ 350 kVA
1Ø Fused Pole (12kV)	0 < connected kVA ≤ 700 kVA
2Ø Fused Pole (6.9kV)	0 < connected kVA ≤ 700 kVA
3Ø Fused Pole CLF	0 < connected kVA ≤ 2,080 kVA (1)
3Ø Fuse Cabinet CLF	0 < connected kVA ≤ 2,080 kVA (4)
3Ø PME Fuse Compartment CLF–140 Amp X–limiter	0 < connected kVA ≤ 1,940 kVA
Fused Elbow CLF (only avail. at 30 Amp)	maximum of 3–1Ø transformers and no more than 135 kVA total maximum of 2–3Ø transformers and no more than 300 kVA total
3Ø PME Fuse Compartment expulsion – 200 amp S&C SM4 fuse (12)	0 < connected kVA ≤ 2,770 kVA
CLF Fuse	kV system ≤ 8.3 (2) and I_f L–G ≥ 1,050A
QA Fuse/Fault Tamer/SMU–20	I_f L–G < 1,050A / or when coordination is required up or down stream

NOTE: For connected load >2,080, kVA, see Design Manual 6205.3 (electronic sectionalizer).

Table 2 - BRANCH FUSE REQUIREMENTS - OVERHEAD

Minimum Branch Exposure (6)	Usage Limitation
2,000 feet	none (7)
1,200 feet	likelihood of severe weather, tree or animal/vehicle contact
none (8)	experienced 3 or more outages in past 3 years

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Table 3 - SUB-BRANCH FUSE REQUIREMENTS (OH & UG)

Minimum Branch Exposure (6)	Usage Limitation
10,000 feet (9)	75% of load (branch and sub-branch included) must be on substation side of sub-branch fuse and the fused sub-branch must be either 2000 feet long without limitation or 1200 feet provided there is a likelihood of severe weather, tree or animal/vehicle contact
none (8)	branch experienced 3 or more outages in past year

NOTES:

(1) Cable pole fusing often represents the lowest installed cost alternative, but is limited to a single run of local distribution cable. When the area load may ultimately exceed the capacity of a single fused cable pole it is necessary to install multiple fuse cabinets served from an unfused cable pole, multiple fused cable poles, or an electronic sectionalizer.

(2) Use of a CLF may be extended to the 12kV system when an expulsion fuse is between the CLF and the 12kV load. This is the case for overhead lines that have a QA, Fault Tamer or SMU-20 fuse installed on the up cable pole and Three-Phase transformers protected by SM-4, weak link or bay-o-net fuses. In the absence of an expulsion fuse, the CLF is likely to sustain an eventful failure while trying to interrupt a 12kV fault, as they are rated @ 8.3 kV.

(3) Fuses with wire elements (such as the fused elbow & EJO) may not be used on 4kV systems because they are capable of producing 25kV during operation. All QA, Combined Tech, ELF, & Kearney B type fuses can be used on 4 kV systems.

(4) Fuse cabinets (whose available I L-G > 1,050A) that are presently equipped with S&C fuses and mini-rupter switch are to be retrofitted with CLF(s). This retrofit will be primarily on new business jobs and only requires adapters for the Kearney type B CLF to fit in the SM-4 or SM-5 fuse holder.

(5) G&W and D&W oil fused cutouts are rated 5.2kV and, therefore, may only be applied to the 4kV system. The G&W cutout has limited fault interrupting compatibility and should be applied as follows: I_f <4200A for 100A cutouts, T_f <8350A for 200A cutouts and, I_f <8550A for 300A cutouts. These cutouts incorporate an expulsion fuse and may be used to provide additional protection, but they may not replace other fused devices that provide CLF protection.

(6) Minimum branch exposure refers to the total branch circuit served by the fuse (main branch and sub-branch included) including overhead and underground areas.

(7) The minimum exposure is based on the historical number of interruptions originating on the local distribution branches that are caused by equipment failure and other non-environmental influences.

(8) A fuse/electronic sectionalizer shall be installed when the cause of the interruption cannot be eliminated. A service restorer may be specified instead of fuse/electronic sectionalizer when the fault is of a self-clearing nature.

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(9) A cascaded sub-branch fuse beyond the local distribution branch fuse is not generally warranted as an economic means to improve circuit reliability. To insure that a significant number of customers would not be affected by a fault beyond the sub-branch fuse, only 25 percent of the branch load is permitted beyond the sub-branch fuse. Additionally, sub-branch fuses on more than one tap should be avoided, unless requested by O&E/C&O Engineering.

(10) No cutout shall be installed where the fault duty exceeds 14,000 Amps sym.

(11) An NX type fuse may be installed on the 4kV system.

(12) All installations of 200 Amp fuses shall be approved by the Fusing Specialist in Electric Distribution Planning and Protection Engineering.

B. New Fuse Installation

A fuse coordination study must be performed by the Fusing Specialist in Electric Distribution Planning each time a new fuse is installed, the substation relay settings change, load is transferred on a fused branch, the size of the largest transformer changes or the size of an existing sectionalizing fuse changes. The fuse coordination study shall consider 3Ø fault current on overhead branches, however, it is acceptable to perform underground studies using calculated line-to-ground fault currents.

1. The coordination study shall include:

   a. A circuit fault analysis to insure the end-of-line fault current within the zone-of-protection of a fuse or relay will exceed the fuse rating or relay setting by the following margins:

      3 times (L-G)
      2 times (3ø)

      (1) The margin (L-G) may be reduced to 2.5 provided the circuit or branch being considered for reduction is underground with a continuous neutral conductor tied solidly to the substation. Further, the protective device may not protect an overhead line via an up cable pole unless the up cable pole is fused with QA, Fault Tamer, or SMU-20 fuses.

      (2) The end-of-line fault current in the relay's zone-of-protection shall be reduced by 100 amps for each grounding bank between the substation and end-of-line. Reduction is not required to insure that adequate fuse coordination exists. (Contact Design Planning if a more precise calculation is desired)

   b. Application of fuse/fuse coordination table(s) to insure that proper coordination exists between sectionalizing fuses.

   c. Application of relay/fuse coordination table to insure proper coordination exists between relays and sectionalizing fuses.

2. Protection Engineering shall be responsible for coordinating customer owned protection (primary metered customers) to SDG&E relays.

3. The Fusing Specialist in Electric Distribution Planning shall specify fuses (properly sized and located to sense the available fault current) at the point on the feeder or local distribution branch where the required fault current margins (B.1.a) exist.

4. CLF protection is not permitted when 12kV overhead lines or 3ø transformers are served, unless coordination is obtained between the CLF and an expulsion fuse installed between the CLF and the 12kV load.

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5. Mis-coordination between a fused cable pole and fuse cabinet is not permitted, therefore, when mis-coordination exists the fuse cabinet shall be bridged.

6. When a 150A CLF cable pole fuse required for transformer coordination would result in bridging a 150A type QA sectionalizing fuse the following should be considered:

   a. Install a smaller QA or Fault Tamer cable pole fuse for $I_f < 2{,}080A$, or;
   b. Bridge the cable pole if a smaller fuse cannot be used or;
   c. Bridge the sectionalizing fuse for $I_f > 2{,}080A$

C. New Fuse Size Selection

The minimum fuse size (current limiting or expulsion) is determined by multiplying the inrush factor by the connected kVA attached to the fuse. The following equations and tables 4 and 5 are used to determine the minimum permissible fuse size.

1. Balanced three-phase system

$$\text{Fuse size, min} = \frac{(\text{Inrush Factor})\ (\text{Total kVA})}{kV_{D3\phi}}$$

2. Unbalanced three-phase system and single phase system (the 3Ø factor zeros out)

$$\text{Fuse size, min} = (\text{Inrush Factor})\left(\frac{3\phi\ \text{kVA}}{kV_{D3\phi}} + \frac{1\phi\ \text{kVA of highest phase}}{kV_{D1\phi}}\right)$$

3. Open Delta three-phase transformer station and single phase system

$$\text{Fuse size, min} = \frac{(\text{Inrush Factor})\ (2/3(3\phi\ \text{kVA}) + \text{largest } 1\phi\ \text{kVA})}{kV_{D1\phi}}$$

* $kV_{D1\phi}$ Could be (L-G) or (L-L)

Table 4 - System Voltage Factors

kV_D	12kV-System	4.16kV-System	2.4kV Delta-System
1Ø (L-G)	6.9/7.2	2.4	--
1Ø (L-L)	N&Y-Type Xfmrs 13.8	4.8	2.4
	H-Type Xfmrs 12		
3Ø	20.8	7.2	4.16

Table 5 - Inrush Factor

Fuse Type/Size	Inrush Factor
Bussman/all sizes	1.5
Combined Tech/all sizes	1.5
D&W/30A & below	2.0
D&W/40A & above	1.5
EJO/all sizes	1.5
ELF/all sizes	1.5
Fault Tamer/all sizes	1.5
FE/all sizes	1.5
KA/40A & below	2.0
KA/50A & above	1.5
KB/all sizes	1.5
NX/all sizes	1.5
QA/all sizes	1.5
RTE/150A	1.5
SM4/all sizes	1.5
SMU-4/ all sizes	1.5

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   a. Install a smaller QA or Fault Tamer cable pole fuse for $I_f < 2{,}080A$, or;
   b. Bridge the cable pole if a smaller fuse cannot be used or;
   c. Bridge the sectionalizing fuse for $I_f > 2{,}080A$

C. New Fuse Size Selection

The minimum fuse size (current limiting or expulsion) is determined by multiplying the inrush factor by the connected kVA attached to the fuse. The following equations and tables 4 and 5 are used to determine the minimum permissible fuse size.

1. Balanced three-phase system

$$\text{Fuse size, min} = \frac{(\text{Inrush Factor})\ (\text{Total kVA})}{kV_{D3\phi}}$$

2. Unbalanced three-phase system and single phase system (the 3Ø factor zeros out)

$$\text{Fuse size, min} = (\text{Inrush Factor})\left(\frac{3\phi\ \text{kVA}}{kV_{D3\phi}} + \frac{1\phi\ \text{kVA of highest phase}}{kV_{D1\phi}}\right)$$

3. Open Delta three-phase transformer station and single phase system

$$\text{Fuse size, min} = \frac{(\text{Inrush Factor})\ (2/3(3\phi\ \text{kVA}) + \text{largest } 1\phi\ \text{kVA})}{kV_{D1\phi}}$$

* $kV_{D1\phi}$ Could be (L-G) or (L-L)

Table 4 - System Voltage Factors

kV_D	12kV-System	4.16kV-System	2.4kV Delta-System
1Ø (L-G)	6.9/7.2	2.4	--
1Ø (L-L)	N&Y-Type Xfmrs 13.8	4.8	2.4
	H-Type Xfmrs 12		
3Ø	20.8	7.2	4.16

Table 5 - Inrush Factor

Fuse Type/Size	Inrush Factor
Bussman/all sizes	1.5
Combined Tech/all sizes	1.5
D&W/30A & below	2.0
D&W/40A & above	1.5
EJO/all sizes	1.5
ELF/all sizes	1.5
Fault Tamer/all sizes	1.5
FE/all sizes	1.5
KA/40A & below	2.0
KA/50A & above	1.5
KB/all sizes	1.5
NX/all sizes	1.5
QA/all sizes	1.5
RTE/150A	1.5
SM4/all sizes	1.5
SMU-4/ all sizes	1.5

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E. Fuse Coordination - Existing Electric Distribution System

A fuse coordination study must be performed by the fusing specialist in Electric Distribution Planning each time a new fuse is installed, the substation relay settings change, load is
transferred on a fused branch, the size of the largest transformer changes or the size of an existing sectionalizing fuse changes. The fuse coordination study shall consider 3ø fault current on overhead branches, however, it is acceptable to perform underground studies using calculated line-to-ground fault currents.

When selecting fuse sizes that serve customer load that already exist the "Fuse Loading Tool" will be used.

This tool makes use of available meter data (including smart meters). The user indicates a starting point, either an existing fuse or a structure, and the tool collects kilowatt hour (kWh) data at each transformer beyond the starting point. The tool records how many meters are reporting and how many are expected to be on the transformer. When meters are not reporting for the particular date range, the most recent thirteen month maximum value for that meter will be used if it is available. Once collected, the kwh data is converted to Amps per phase using the following calculation, and be displayed as "max kWh".

For Fuse Qty 1:
[(Summed Single Phase kWh + max kWh + Planned Single Phase kWh) / 6.93] x 1.265
(cold load & growth factor)

For Fuse Qty 2:
[(((summed single phase kWh + (max kWh/ 2)) * 1.2) + planned single phase kWh)/12] x 1.265

For Fuse Qty 3:
[(((Summed Three Phase kWh + Max Three Phase kWh + Planned Three Phase kWh) /3)
* 1.2) + (summed Single Phase kWh + max kWh + Planned Single Phase kWh)) /20.8] x 1.265

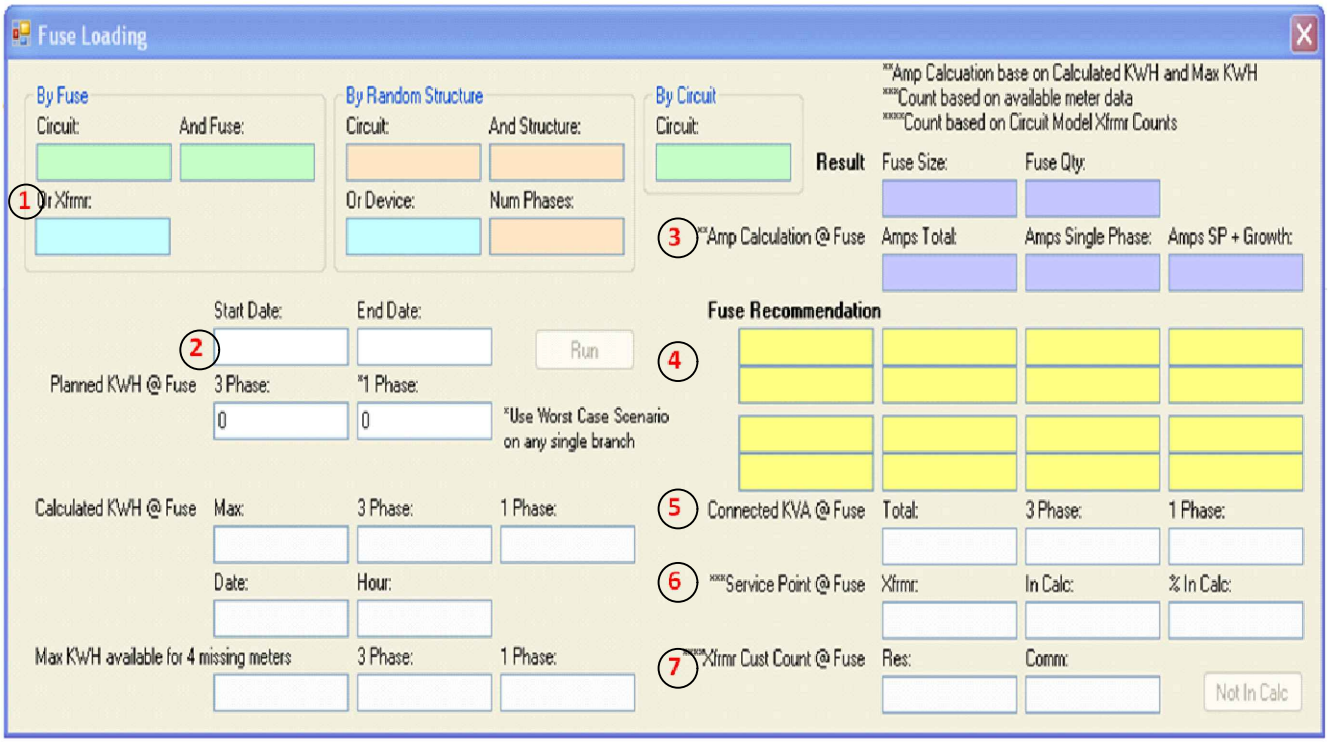
Recommended fuse sizes are based on a table provided by System Protection and Control Engineering (SPACE) and uses OH/UG designation and the Single Phase plus Growth value.

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FUSE LOADING TOOL



NOTE: Numbers below correspond to the numbers shown in the example above.

(1) Enter Circuit ID and the pole or pad ID of the existing fuse location or Circuit ID and Transformer (Xfmr) ID. This item is manually input by the Fusing Specialist.

(2) To capture peak load downstream of the input device, start date is defaulted to 1/1/2010 and end date is defaulted to two days prior to current date.

Items 3 through 7 are auto populated after the "Run" button is selected.

(3) This calculation is the total amps downstream of the selected fuse based on Smart Meter data. "Amps Sp + Growth" factors is cold load pick-up and a growth factor.

(4) Recommended size for all fuse types currently in the stock table. The Fusing Specialist will determine the proper fuse size and type for the given location.

(5) Connected kVA of transformers (both three phase and single phase) downstream of the given location.

(6) Service points downstream of given location, and the number used in the "Amp Calculation".

(7) Breakdown of customer count (residential and commercial) downstream of selected fuse.

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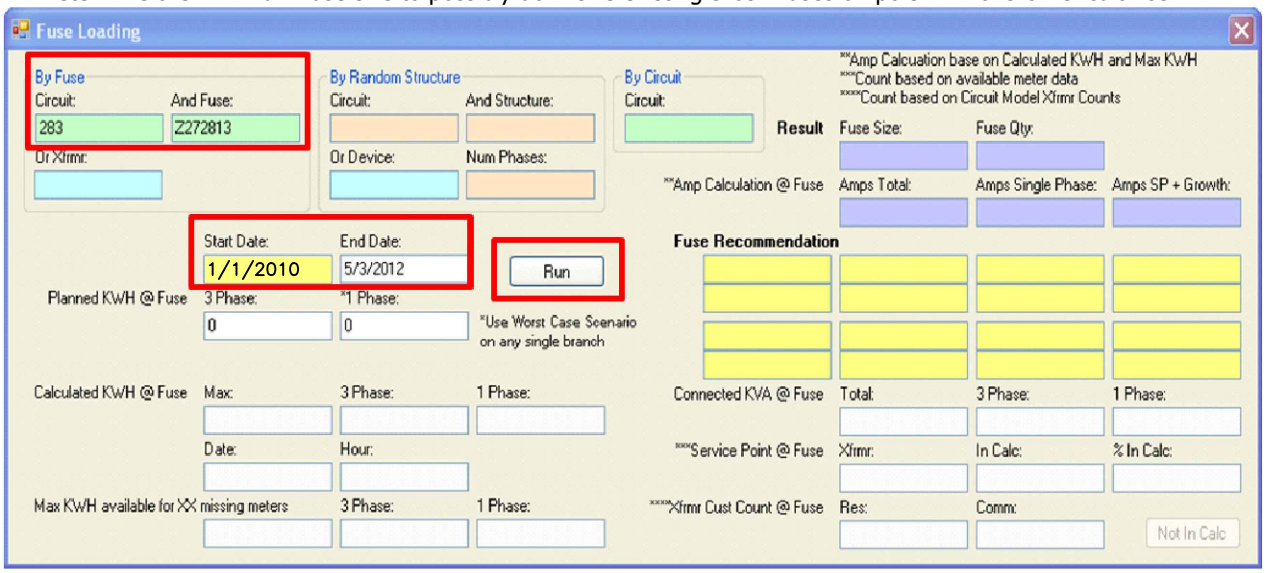
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Examples

1. Determine the minimum fuse size to possibly downsize existing 3-65A fuses on pole Z272813 on Circuit 283.

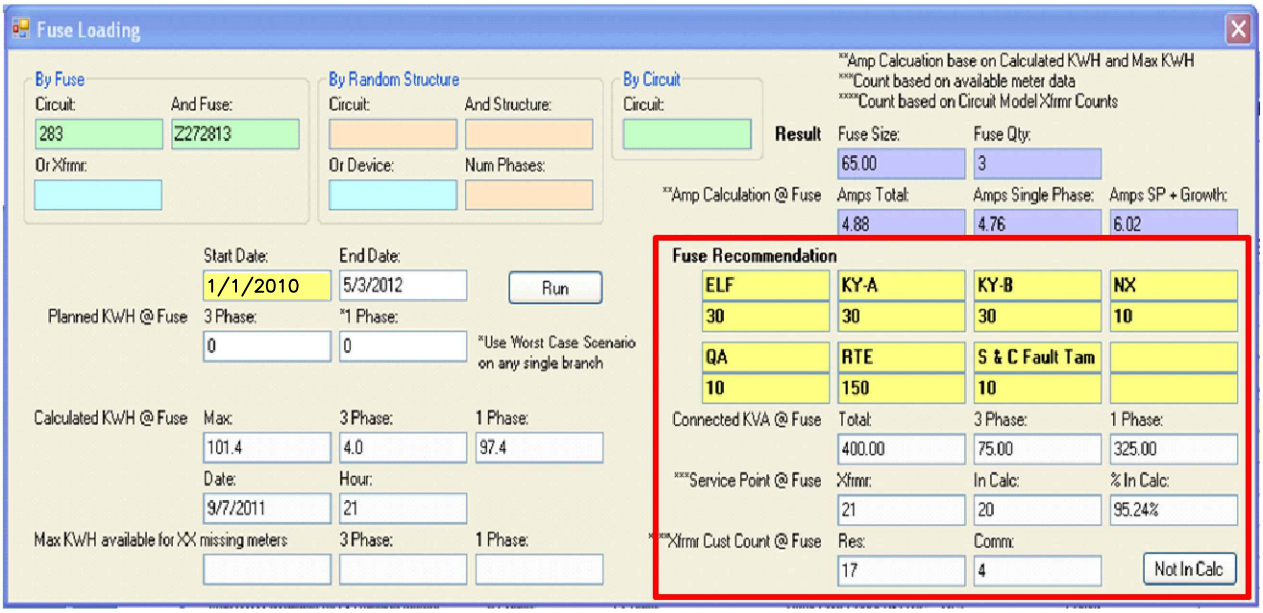


a. Input Circuit ID and the pole number of the fuse location.

b. The start date is defaulted to 1/1/2010 and the end date is defaulted to two days prior to the current date. The current date in this example is 5/5/12.

c. Click "Run".

Results



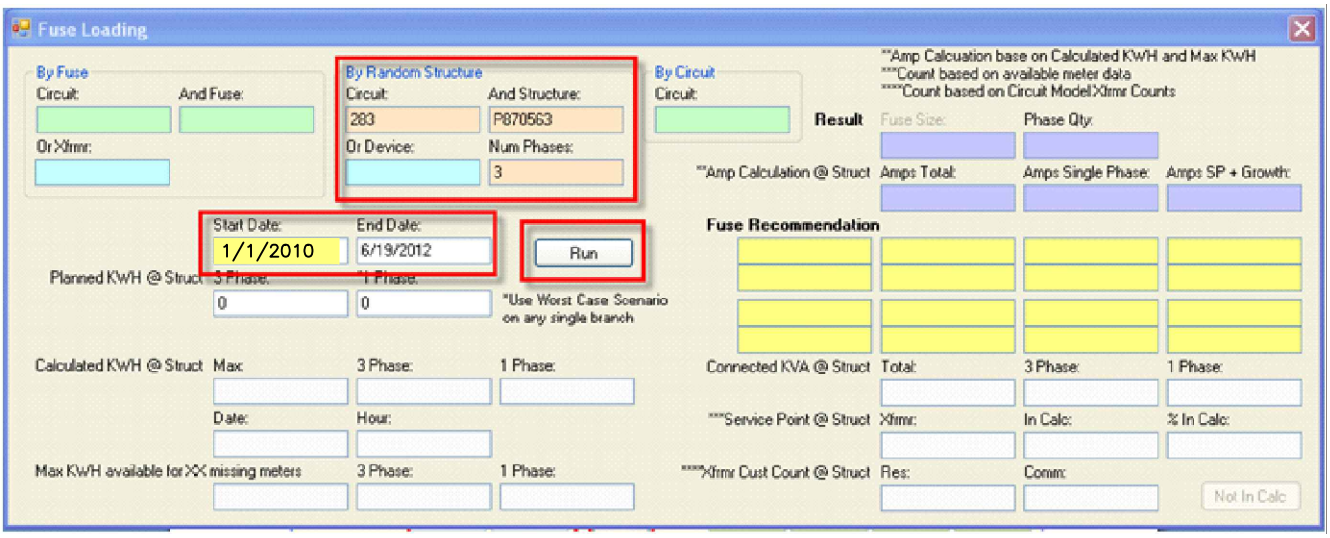
a. The Fusing Specialist will determine the proper fuse size from the given selection of fuse recommendations. If a current limiting fuse cannot be installed then the Fault Tamer fuse should be installed whenever possible, especially in High Fire Threat Districts Tier-2 and Tier-3.

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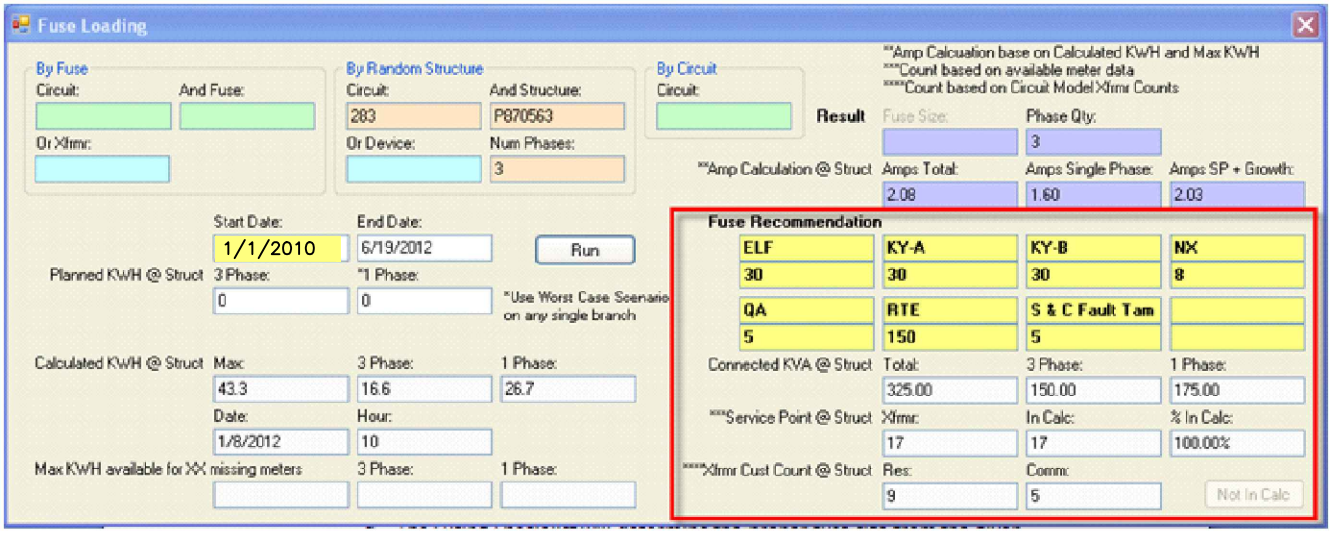
2. Determine the proper fuse size for a new fuse location directly upstream from pole P870563 on Circuit 283.



a. Input Circuit ID and the pole number of the proposed location on the branch in question.

b. The start date is defaulted to 1/1/2010 and the end date is defaulted to two days prior to the current date. The current date in this example is 6/21/12.

c. Click "Run".



d. The Fusing Specialist will determine the proper fuse size from the given selection of fuse recommendations. If a current limiting fuse cannot be installed then the Fault Tamer fuse should be installed whenever possible, especially in High Fire Threat Districts Tier-2 and Tier-3.

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SCOPE

This standard provides criteria for using the transformer/sectionalizing fuse coordination tables. These tables will be used by the Electric Distribution Planning when coordinating sectionalizing fuses on local distribution systems.

TRANSFORMER/SECTIONALIZING FUSE COORDINATION TABLES

Each sectionalizing fuse shall be sized to coordinate with transformer fuses except those situations meeting the single station fusing criteria (table 1). The following procedure is only for obtaining coordination between trans-formers and sectionalizing fuses.

Table I

Single station installations where coordination is not required with sectionalizing fuses.

Fuse Type and Voltage Rating (kV)		1ø 2.4 kV	3ø 2.4,4.16kV	1ø 6.9,7.2kV	1ø 12kV	3ø 12kV
Combined Tech X-Limiter	8.3	x	x	x		
Combined Tech EOD/SD	8.3	x	x	x		
Cooper ELF	8.3	x	x	x	(4)	(4)
D&W	5.2	x	x			
F.E.	8.3	(3)	(3)	x		
GE EJO-1	7.2	(3)	(3)	x		
Kearney QA	14.4	x	x	x	x	x
Kearney A	8.3	x	x	x		
Kearney B	8.3	x	x	x	(4)	(4)
McG-Ed NX	8.3	x	x	x		
McG-Ed NX	15.5	x	x	x	x	x
RTE	8.3	x	x	x	(4)	(4)
S&C SM-4	14.4	x	x	x	x	x

Required information:

1) The size and type of <u>all</u> underground transformers, connected directly to the sectionalizing fuse, but preceding any downstream sectionalizing fuses. (e.g. 25NDD, 75HZR...)

2) The <u>type</u> of sectionalizing fuse to be sized. (e.g. Type "B", EJO-1...)

Required information: Con't

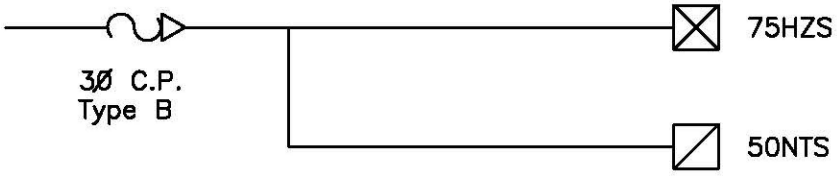
(3) Fuses with wire elements may not be used on the 4kV system because they are capable of producing 25kV during operation.

(4) An 8.3kV fuse may serve a 12kV transformer which it does not coordinate with if the fuse is installed on a cable pole. We do not permit miscoordination between a padmounted 8.3kV CLF and a 12kV transformer.

(5) The Fault Tamer should not be used on the 2.4kV or 4kV system because it will not coordinate with the 3kV lightning arrester used on those systems.

Using the above information, determine the minimum sectionalizing fuse required for coordination with each transformer. This is done by locating the specific transformer type and size on the following pages. The required fuse size can then be read from the appropriate column. The minimum required sectionalizing fuse will be the largest of these fuses.

EXAMPLE:



Minimum sectionalizing fuse required for coordination with transformers:

50 NTS – 80 amp Type B from table on page 6131.3

75 HZS – 30 amp Type B from table on page 6131.5

Fuse size required on cable pole for coordination – 80 amp Type B

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UNDERGROUND TRANSFORMER/FUSE COORDINATION TABLES

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MINIMUM SECTIONALIZING FUSE REQUIRED FOR COORDINATION WITH TRANSFORMER (AMPERE RATING)

TRANSF. PREFIX	TYPE OF TRANSF. FUSES	SIZE OF TRANSF. (KVA)	TRANSF. FULL LOAD CURRENT (AMPS)	KEARNEY QA	(6) FAULT TAMER	S&C SM-4	(6) GE EJO-1/ COMBINED TECHNOLOGIES EOD/SD	(6) COOPER ELF	(6) KEARNEY TYPE B	(6)(15) COMBINED TECHNOLOGIES X-LIMITER	(6)(7) KEARNEY TYPE A	(6)(14) ELASTIMOLD F.E.	(5)(6) McG-ED 'NX'	D&W OIL FUSE CUTOUT
NCS NDS* NTS	BAY-O-NET D.E.W.L.													
NDL*	or	15	2.2	15	15	10	40	30	30	140	40	18 (13)	25	--
NSL*	INTERNAL	25	3.6	20	15	15	65	30	30	140	50	18 (13)	25	--
NTD*	WEAK LINK	50	7.2	50	20	40	80	65	80	140	50	30	40	--
NDD*	(6.9kV)1Ø	75	10.8	60	--	50	100	65	80	140	--	--	2X30	--
NSD*	Deadfront	100	14.4	60	--	50	150	65	150 (8)(9)	140	--	--	2X40	--
NEP*	Livefront													
NTP*	INTERNAL	25	3.6	20	--	15	80	30	30	140	50	18 (13)	25	--
NDP*	WEAK LINK	50	7.2	50	--	30	80	30	30	140	50	18 (13)	30	--
NTQ*	(6.9kV)1Ø	75	10.8	60	--	50	80	65	80	140	65	30	2X30	--
	Deadfront	100	14.4	75	--	65	100	65	150 (8)(9)	140	--	--	2X30	--
NES (12)	INTERNAL WEAK LINK (6.9kV)1Ø Deadfront	50	7.2	50	--	40	80	65	80	140	50	30	40	--
		100	14.4	60	--	50	150	65	150 (8)(9)	140	--	--	2X40	--
YDP*YES*	INTERNAL	15	2.1	20	--	15	80	30	30	140	50	18 (13)	18	--
YSV*YTP*	WEAK LINK	25	3.5	25	--	30	80	30	30	140	50	18 (13)	25	--
YDQ*	(7.2kV)1Ø	50	6.9	50	--	40	100	65	80	140	65	--	40	--
	Deadfront	75	10.4	75	--	65	150	65	150 (8)(9)	140	--	--	2X30	--
YEP*	Livefront	100	13.9	100	--	80	150	--	150 (8)(9)	140	--	--	2X40	--
YIS*	BAY-O-NET (7.2kV)1Ø Deadfront	50	6.9	20	--	15	80	30	80	140	50	30	30	--
YP*	EXTERNAL NX FUSES (7.2kV)1Ø Livefront	15	2.1	25	--	15	40	30	30	140	30	18 (13)	12	--
		25	3.5	25	--	15	40	30	30	140	30	18 (13)	18	--
		50	6.9	40	--	30	80	30	80	140	50	30	30	--
		75	10.4	75	--	50	80	65	80	140	50	30	40	--
		100	13.9	100	--	80	80	65	80	140	65	--	2X30	--
		167	23.2	125	--	100	150	--	150 (8)(9)	140	--	--	2X40	--
WEP*	INTERNAL	15	6.3	40	--	30	80	30	80	140	50	30	40	50
		25	10.4	60	--	50	100	65	80	140	65	--	2X30	65
WEQ*	WEAK LINK	37.5	15.6	100	--	80	150	65	150 (8)(9)	140	65	--	2X40	100
	(2.4kV)1Ø	50	20.8	125	--	100	150	65	150 (8)(9)	140	--	--	2X40	125
WUS*	Deadfront	75	31.3	150	--	125	200 (2)	--	--	140	--	--	--	150
		100	41.6	200 (2)(4)	--	200 (2)	--	--	--	140	--	--	--	200 (2)

*No longer installed as standard unit.

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MINIMUM SECTIONALIZING FUSE REQUIRED FOR COORDINATION WITH TRANSFORMER (AMPERE RATING)

TRANSF. PREFIX	TYPE OF TRANSF. FUSES	SIZE OF TRANSF. (KVA)	TRANSF. FULL LOAD CURRENT (AMPS)	KEARNEY QA	(6) FAULT TAMER	S&C SM-4	(6) GE EJO-1/ COMBINED TECHNOLOGIES EOD/SD	(6) COOPER ELF	(6) KEARNEY TYPE B	(6)(15) COMBINED TECHNOLOGIES X-LIMITER	(6)(7) KEARNEY TYPE A	(6)(14) ELASTIMOLD F.E.	(5)(6) McG-ED 'NX'	D&W OIL FUSE CUTOUT
NCS NDS* NTS	BAY-O-NET D.E.W.L.													
NDL*	or	15	2.2	15	15	10	40	30	30	140	40	18 (13)	25	--
NSL*	INTERNAL	25	3.6	20	15	15	65	30	30	140	50	18 (13)	25	--
NTD*	WEAK LINK	50	7.2	50	20	40	80	65	80	140	50	30	40	--
NDD*	(6.9kV)1Ø	75	10.8	60	--	50	100	65	80	140	--	--	2X30	--
NSD*	Deadfront	100	14.4	60	--	50	150	65	150 (8)(9)	140	--	--	2X40	--
NEP*	Livefront													
NTP*	INTERNAL	25	3.6	20	--	15	80	30	30	140	50	18 (13)	25	--
NDP*	WEAK LINK	50	7.2	50	--	30	80	30	30	140	50	18 (13)	30	--
NTQ*	(6.9kV)1Ø	75	10.8	60	--	50	80	65	80	140	65	30	2X30	--
	Deadfront	100	14.4	75	--	65	100	65	150 (8)(9)	140	--	--	2X30	--
NES (12)	INTERNAL WEAK LINK (6.9kV)1Ø Deadfront	50	7.2	50	--	40	80	65	80	140	50	30	40	--
		100	14.4	60	--	50	150	65	150 (8)(9)	140	--	--	2X40	--
YDP*YES*	INTERNAL	15	2.1	20	--	15	80	30	30	140	50	18 (13)	18	--
YSV*YTP*	WEAK LINK	25	3.5	25	--	30	80	30	30	140	50	18 (13)	25	--
YDQ*	(7.2kV)1Ø	50	6.9	50	--	40	100	65	80	140	65	--	40	--
	Deadfront	75	10.4	75	--	65	150	65	150 (8)(9)	140	--	--	2X30	--
YEP*	Livefront	100	13.9	100	--	80	150	--	150 (8)(9)	140	--	--	2X40	--
YIS*	BAY-O-NET (7.2kV)1Ø Deadfront	50	6.9	20	--	15	80	30	80	140	50	30	30	--
YP*	EXTERNAL NX FUSES (7.2kV)1Ø Livefront	15	2.1	25	--	15	40	30	30	140	30	18 (13)	12	--
		25	3.5	25	--	15	40	30	30	140	30	18 (13)	18	--
		50	6.9	40	--	30	80	30	80	140	50	30	30	--
		75	10.4	75	--	50	80	65	80	140	50	30	40	--
		100	13.9	100	--	80	80	65	80	140	65	--	2X30	--
		167	23.2	125	--	100	150	--	150 (8)(9)	140	--	--	2X40	--
WEP*	INTERNAL	15	6.3	40	--	30	80	30	80	140	50	30	40	50
		25	10.4	60	--	50	100	65	80	140	65	--	2X30	65
WEQ*	WEAK LINK	37.5	15.6	100	--	80	150	65	150 (8)(9)	140	65	--	2X40	100
	(2.4kV)1Ø	50	20.8	125	--	100	150	65	150 (8)(9)	140	--	--	2X40	125
WUS*	Deadfront	75	31.3	150	--	125	200 (2)	--	--	140	--	--	--	150
		100	41.6	200 (2)(4)	--	200 (2)	--	--	--	140	--	--	--	200 (2)

*No longer installed as standard unit.

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6131.4 UNDERGROUND TRANSFORMER/FUSE COORDINATION TABLES

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TRANSF. PREFIX	TYPE OF TRANSF. FUSES	SIZE OF TRANSF. (KVA)	TRANSF. FULL LOAD CURRENT (AMPS)	KEARNEY QA	⑥ FAULT TAMER	S&C SM-4	⑥ GE EJO-1/ COMBINED TECHNOLOGIES EOD/SD	⑥ COOPER ELF	⑥ KEARNEY TYPE B	⑥⑮ COMBINED TECHNOLOGIES X-LIMITER	⑥⑦ KEARNEY TYPE A	⑥⑭ ELASTIMOLD F.E.	⑤⑥ McG-ED 'NX'	D&W OIL FUSE CUTOUT
SDD* ③	INTERNAL WEAK LINK 2.4/6.9kV 1Ø D.F.	25	10.4	75	--	50	150	65	80	140	--	--	30	65
		50	20.8	100	--	80	200 ②	--	150 ⑧⑨	140	--	--	2X30	125
(WDD)		75	31.3	150	--	125	--	--	--	140	--	--	2X40	150
WDS SDS SID* ⑩ 2.4kV	BAY-O-NET D.E.W.L. 2.4/6.9kV 1Ø D.F.	25	10.4	75	--	50	150	65	80	140	--	--	30	65
		50	20.8	100	--	80	200 ②	--	150 ⑧⑨	140	--	--	2X30	125
		75	31.3	150	--	125	--	--	--	--	--	--	2X40	150
WDS SDS SID* ⑩ 6.9kV	BAY-O-NET D.E.W.L. 2.4/6.9kV 1Ø D.F.	25	3.6	20	15	15	80	30	30	140	50	30	25	--
		50	7.2	50	20	40	80	65	80	140	50	30	40	--
		75	10.8	60	--	50	100	65	80	140	--	--	2X30	--
HEP*	INTERNAL WEAK LINK (12kV)1Ø Livefront	15	1.3	10④	--	10	40	30	30	140	30	30	12	--
		25	2.1	10④	--	10	40	30	30	140	30	30	12	--
HEQ*		37.5	3.1	20	--	15	40	30	30	140	30	30	18	--
		50	4.2	25	--	30	40	30	30	140	30	30	18	--
HJP*		75	6.2	40	--	30	80	30	80	140	50	30	30	--
		100	8.3	50	--	40	80	65	80	140	50	30	30	--
HDS HTS HJS HDL* HDD* HTD* HSL* HTL* HJD* HJL*	BAY-O-NET D.E.W.L. or INTERNAL WEAK LINK (12kV)1Ø Deadfront	15	1.3	15	15	10	40	30	30	140	30	30	10	--
		25	2.1	15	15	10	40	30	30	140	30	30	12	--
		50	4.2	25	15	15	80	30	30	140	50	30	20	--
		75	6.2	30	20	30	80	30	80	140	50	30	30	--
		100	8.3	50	--	40	80	65	80	140	50	30	40	--
		167	13.9	60	--	50	150	65	150 ⑧⑨	140	--	--	2X30	--
HP*	EXTERNAL NX FUSES (12kV)1Ø Livefront	25	2.1	25	--	15	40	30	30	140	30	30	12	--
		50	4.2	25	--	15	40	30	30	140	30	30	18	--
		75	6.2	30	--	30	40	30	30	140	40	30	30	--
		100	8.3	40	--	30	80	30	80	140	50	30	30	--
HQ*		167	13.9	75	--	65	80	65	80	140	50	30	2X30	--
HSS HST	BAY-O-NET D.E.W.L. or INTERNAL WEAK LINK (12kV)1Ø Deadfront	25	2.1	15	15	15	40	30	30	140	30	30	18	--
		50	4.2	30	15	20	80	30	80	140	50	30	30	--
		75	6.2	40	20	30	80	30	80	140	50	30	40	--
		100	8.3	50	--	40	80	65	150 ⑧⑨	140	65	--	2X30	--

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PXS PZS PZR* (11) PZB* ⊙ 4kV	BAY-O-NET D.E.W.L. 4/12kV 3Ø Deadfront	75 150 500	10.4 20.8 69.4	-- -- --	-- -- --	65 100 200 (2)	100 150 --	65 -- --	150 (8)(9) 150 (8)(9) --	140 140 --	-- -- --	-- -- --	2x30 -- --	75 100 --
PXS PZS PZR* (11) PZB* ⊙ 12kV	BAY-O-NET D.E.W.L. 4/12kV 3Ø Deadfront	75 150 500	3.6 7.2 24.1	15 20 125	15 20 --	15 30 100	80 80 150	30 65 65	30 80 150 (8)(9)	140 140 140	40 50 --	18 (13) 30 --	25 40 2x40	-- -- --
WXP*	INTERNAL WEAK LINK (4kV) 3Ø	75 150	10.4 20.8	60 100	-- --	50 80	100 150	65 --	80 150 (8)(9)	140 140	-- --	-- --	2x30 --	65 125
WZP*	INTERNAL WEAK LINK (4kV) 3Ø Livefront	75 112.5 150	10.4 15.6 20.8	50 75 100	-- -- --	40 65 80	100 150 200 (2)	65 -- --	80 150 (8)(9) 150 (8)(9)	140 140 140	-- -- --	-- -- --	2x30 2x40 --	65 75 125
HNS HZS HPS HBS HKS HAL* HZR* HKR* HZL* HPR* HNL* HAB* HZB* HKB* HNB* HPB*	BAY-O-NET D.E.W.L. (12kV) 3Ø Deadfront	45 75 150 225 300 500	2.2 3.6 7.2 10.8 14.4 24.1	20 20 30 50 75 125	15 15 20 -- -- --	15 15 30 40 65 100	40 80 80 80 100 150	30 30 65 65 65 --	30 30 80 80 80 150 (8)(9)	140 140 140 140 140 140	40 40 50 65 -- --	18 (13) 18 (13) 30 -- -- --	25 25 40 2x30 2x30 2x40	-- -- -- -- -- --
HMB* HML* HMS	BAY-O-NET D.E.W.L. (12kV) 3Ø Deadfront	75 150 225 300	3.6 7.2 10.8 14.4	20 30 50 75	15 20 -- --	15 30 40 65	80 80 100 150	30 65 65 --	30 80 150 (8)(9) 150 (8)(9)	140 140 140 140	40 50 65 --	18 (13) 30 -- --	25 40 2x30 2x40	-- -- -- --

*No longer installed as standard unit.

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HPS HBS HNS HPB* HPR* HAB* HAL* HNB* HNL*	BAY-O-NET (12kV) 3Ø Deadfront	750	36.1	200	--	125	150	--	150 (8)(9)	140	--	--	2x40	--
		1000	48.1	200 (2)(4)	--	125	150	--	150 (8)(9)	140	--	--	2x40	--
HZP* HZQ*	INTERNAL WEAK LINK (12kV) 3Ø Livefront	75	3.6	20	--	15	80	30	30	140	50	18 (13)	25	--
		112.5	5.4	40	--	30	80	65	80	140	50	30	40	--
		150	7.2	40	--	40	80	65	80	140	65	30	2x30	--
HAP* HAQ* HLP* HMP* HPP*	EXTERNAL NX FUSES (12kV) 3Ø Livefront	75	3.6	25	--	30	40	30	30	140	30	18 (13)	20	--
		150	7.2	40	--	30	80	30	80	140	50	30	40	--
		225	10.8	75	--	50	80	65	80	140	50	--	2x30	--
		300	14.4	100	--	80	100	65	150 (8)(9)	140	65	--	2x40	--
		500	24.1	150	--	125	150	--	150 (8)(9)	140	--	--	2x40	--
		750	36.1	150	--	125	150	--	150 (8)(9)	140	--	--	--	--
		1000	48.1	200 (2)(4)	--	200 (2)	200 (2)	--	--	--	--	--	--	--
HLS HMP* HAP* HPP*	EXTERNAL S&C SM-4 (12kV) 3Ø Livefront	1500	72.2	200 (2)(4)	--	200 (2)	--	--	--	--	--	--	--	--
		2000	96.2	200 (2)(4)	--	--	--	--	--	--	--	--	--	--
		2500	120.2	--	--	--	--	--	--	--	--	--	--	--
		3000	144.4	--	--	--	--	--	--	--	--	--	--	--
HXP*	INTERNAL WEAK LINK (12kV) 3Ø Livefront	75	3.6	20	--	15	80	30	30	140	50	18 (13)	25	--
		112.5	5.4	30	--	30	80	30	80	140	50	30	30	--
		150	7.2	50	--	30	80	65	80	140	50	30	40	--
HPS HNS HBS HAB* HNB* HNR* HPR*	HIGH AMPERE BAY-O-NET (12kV) 3Ø Deadfront	1500	72.2	200 (2)(4)	--	200 (2)	--	--	--	--	--	--	--	--
		2000	96.2	200 (2)(4)	--	--	--	--	--	--	--	--	--	--
		2500	120.3	200 (2)(4)	--	--	--	--	--	--	--	--	--	--

*No longer installed as standard unit.

NOTES:

(2) All installations of 200 amp fuses shall be approved by the Fusing Specialist in Electric Distribution Planning and Protection Engineering.

(3) Series/multiple primary – fusing listed applies to either 2.4/6.9 or 4/12kV.

(4) These fuses are Kearney Type 200's, not QA's.

(5) Fuse sizes listed apply to either 8.3 or 15kV rated CLF's (current–limiting fuses).

(6) These fuses are CLF.

(7) These fuses are used only in single–phase fuse cabinets.

(8) The 150 amp Type B CLF is only used in S&C 30 fuse cabinets and vaults.

(9) The RTE Type SD or Combined Technologies BOI 150 amp cable pole CLF should be used for this application.

(10) When changing SID/SDS from 2.4kV to 6.9kV follow Bay–o–net fuse chart listed:

SID/SDS	2.4kV	6.9kV
25kVA	15 amp	6 amp
50kVA	40 amp	12 amp
75kVA	50 amp	15 amp

Series/multiple primary transformers are supplied with 2.4kV fuse.

(11) When changing PZR/PZB/PZS/PXS from 4kV to 12kV follow Bay–o–net fuse chart listed:

PZR/PZB/PZS/PXS	4kV	12kV
75kVA	15 amp	6 amp
150kVA	30 amp	12 amp
225kVA	40 amp	15 amp
500kVA	100 amp	40 amp

Series/multiple primary transformers are supplied with 4160 volt fuse.

(12) NES – replacement for "YES" and "HSS"

(13) 18A Fused elbow is no longer purchased.

(14) Fused elbows should never be installed to serve unfused 12kV transformers.

(15) This fuse is only used in PME 9 and PME 11 switchgear.

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SCOPE

The following criteria shall be followed when using current–limiting protecting fuse coordination tables.

DEFINITION

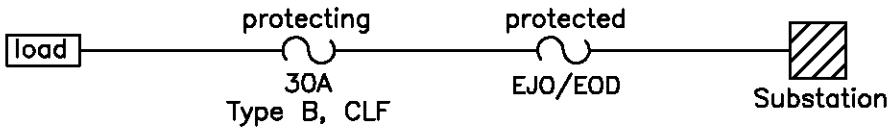
Protecting Fuse – refers to the fuse closest to the load with repect to the "protected" fuse.

CURRENT–LIMITING PROTECTING FUSE COORDINATION TABLE

To insure that proper coordination is obtained between protecting and protected fuses, the following information is required:

1. The size and type of current–limiting fuse, (e.g., 30 amp EOD/EJO–1)
2. The type of protected sectionalizing fuse to be sized, (e.g., SM–4)
3. The maximum available fault current at the protecting fuse location.

Example:



Maximum protecting available fault current at the 30 amp fuse is 1200 amps.

The minimum size protected fuse required for coordination is a 100 amp, EJO/EOD (refer to page 6132.2).

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)												
		GE EJO–1 COMBINED TECHNOLOGIES EOD/SD								KEARNEY TYPE A				COOPER X–LIMITER
		30 (A)	40	50 (A)	65 (A)	80	100	150	200	30 (A)	40	50 (A)	65	140A
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
GE EJO–1 COMBINED TECHNOLOGIES EOD/SD	30	–	–	250	680	1200	1500	*	*	–	–	700	1000	*
	40	–	–	–	510	1000	1400	*	*	–	–	650	900	*
	50	–	–	–	–	720	1250	2700	*	–	–	–	800	*
	65	–	–	–	–	–	780	2500	*	–	–	–	–	*
	80	–	–	–	–	–	–	2000	3500	–	–	–	–	4100
	100	–	–	–	–	–	–	1500	3000	–	–	–	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–	–
	200	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE B	30	–	–	–	–	–	*	*	*	–	–	100	*	*
	80	–	–	–	–	–	250	*	*	–	–	–	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE A	30	–	–	130	*	*	*	*	*	–	–	*	*	*
	40	–	–	100	*	*	*	*	*	–	–	850	*	*
	50	–	–	–	–	–	–	*	*	–	–	–	–	*
	65	–	–	–	–	–	–	*	*	–	–	–	–	*
McGRAW–EDISON/COOPER NX	8	*	*	*	*	*	*	*	*	*	*	*	*	*
	10	130	400	*	*	*	*	*	*	180	400	*	*	*
	12	70	120	450	*	*	*	*	*	120	200	*	*	*
	18	–	–	–	*	*	*	*	*	55	90	*	*	*
	20	–	–	–	150	*	*	*	*	50	80	*	*	*
	25	–	–	–	–	200	*	*	*	–	70	800	*	*
	30	–	–	–	–	–	250	*	*	–	–	150	850	*
	40	–	–	–	–	–	–	*	*	–	–	–	160	*
ELASTIMOLD FUSED ELBOW	18	–	–	–	170	*	*	*	*	55	100	*	*	*
	30	–	–	–	–	–	310	*	*	–	–	230	500	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

(A) NOT BEING ORDERED

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)																
		S&C SM-4											KEARNEY TYPE B			COOPER ELF	
		10	15	30	40	50	65	80	100	125	150	200	30	80	150	30	65
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION															
GE EJO-1 COMBINED TECHNOLOGIES EOD/SD	30	–	–	–	1400	*	*	*	*	*	*	*	–	–	2000	–	1500
	40	–	–	–	–	–	*	*	*	*	*	*	–	–	1900	–	1300
	50	–	–	–	–	–	–	*	*	*	*	*	–	–	1700	–	1200
	65	–	–	–	–	–	–	–	3700	*	*	*	–	–	1600	–	–
	80	–	–	–	–	–	–	–	–	5000	*	*	–	–	1500	–	–
	100	–	–	–	–	–	–	–	–	4500	6000	–	–	–	1400	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	200	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE B	30	–	–	–	–	–	–	*	*	*	*	*	–	–	*	–	–
	80	–	–	–	–	–	–	–	*	*	*	*	–	–	*	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE A	30	–	–	–	–	*	*	*	*	*	*	*	–	*	*	–	*
	40	–	–	–	–	–	*	*	*	*	*	*	–	*	*	–	*
	50	–	–	–	–	–	–	–	–	*	*	*	–	–	*	–	–
	65	–	–	–	–	–	–	–	–	–	*	*	–	–	*	–	–
McGRAW-EDISON/COOPER NX	8	–		*	*	*	*	*	*	*	*	*	*	*	*	*	*
	10	–	–	*	*	*	*	*	*	*	*	*	–	*	*	*	*
	12	–	–	*	*	*	*	*	*	*	*	*	–	*	*	*	*
	18	–	–	–	–	*	*	*	*	*	*	*	–	*	*	50	*
	20	–	–	–	–	–	*	*	*	*	*	*	–	*	*	55	*
	25	–	–	–	–	–	–	*	*	*	*	*	–	*	*	–	*
	30	–	–	–	–	–	–	–	*	*	*	*	–	–	*	–	*
	40	–	–	–	–	–	–	–	–	*	*	*	–	–	*	–	–
ELASTIMOLD FUSED ELBOW	18	–	–	–	–	*	*	*	*	*	*	*	–	*	*	57	*
	30	–	–	–	–	–	–	*	*	*	*	*	–	–	*	–	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate within current-limiting region.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)												
		KEARNEY QA												RTE
		15	20	25	30	40	50	60	75	100	125	150	200	150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
GE EJO–1 COMBINED TECHNOLOGIES EOD/SD	30	–	–	–	–	–	–	1700	*	*	*	*	*	*
	40	–	–	–	–	–	–	–	*	*	*	*	*	*
	50	–	–	–	–	–	–	–	–	*	*	*	*	*
	65	–	–	–	–	–	–	–	–	–	*	*	*	*
	80	–	–	–	–	–	–	–	–	–	–	5000	*	2000
	100	–	–	–	–	–	–	–	–	–	–	–	*	–
	150	–	–	–	–	–	–	–	–	–	–	–	7500	–
	200	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE B	30	–	–	–	–	–	–	–	–	*	*	*	*	*
	80	–	–	–	–	–	–	–	–	–	–	*	*	*
	150	–	–	–	–	–	–	–	–	–	–	–	–	–
KEARNEY TYPE A	30	–	–	–	–	–	–	*	*	*	*	*	*	*
	40	–	–	–	–	–	–	–	*	*	*	*	*	*
	50	–	–	–	–	–	–	–	–	–	–	*	*	*
	65	–	–	–	–	–	–	–	–	–	–	–		*
McGRAW–EDISON/COOPER NX	8	–	–	*	*	*	*	*	*	*	*	*	*	*
	10	–	–	–	*	*	*	*	*	*	*	*	*	*
	12	–	–	–	–	*	*	*	*	*	*	*	*	*
	18	–	–	–	–	–	–	–	*	*	*	*	*	*
	20	–	–	–	–	–	–	–	*	*	*	*	*	*
	25	–	–	–	–	–	–	–	–	*	*	*	*	*
	30	–	–	–	–	–	–	–	–	–	*	*	*	*
	40	–	–	–	–	–	–	–	–	–	–	*	*	*
ELASTIMOLD FUSED ELBOW	18	–	–	–	–	–	–	*	*	*	*	*	*	*
	30	–	–	–	–	–	–	–	–	*	*	*	*	*
RTE	150	–	–	–	–	–	–	–	–	–	–	–	*	–
COOPER ELF	30	–	–	–	–	–	–	–	*	*	*	*	*	*
	65	–	–	–	–	–	–	–	–	–	–	*	*	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate within current–limiting region.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)									
		McGRAW–EDISON/COOPER NX								ELASTIMOLD FUSED ELBOW	
		8	10	12	18	20	25	30	40	18 Ⓐ	30
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
KEARNEY TYPE A	30	–	–	–	–	–	–	*	*	–	–
	40	–	–	–	–	–	–	–	*	–	–
	50	–	–	–	–	–	–	–	–	–	–
	65	–	–	–	–	–	–	–	–	–	–
McGRAW–EDISON/COOPER NX	8	–	*	*	*	*	*	*	*	*	*
	10	–	–	–	–	–	–	*	*	–	*
	12	–	–	–	–	–	–	–	*	–	*
	18	–	–	–	–	–	–	–	*	–	*
	20	–	–	–	–	–	–	–	*	–	–
	25	–	–	–	–	–	–	–	–	–	–
	30	–	–	–	–	–	–	–	–	–	–
	40	–	–	–	–	–	–	–	–	–	–
ELASTIMOLD FUSED ELBOW	18	–	–	–	–	–	–	–	*	–	*
	30	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate within current–limiting region.

Ⓐ NOT BEING ORDERED

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SCOPE

The following criteria shall be followed when using the expulsion protecting fuse coordination tables.

DEFINITION

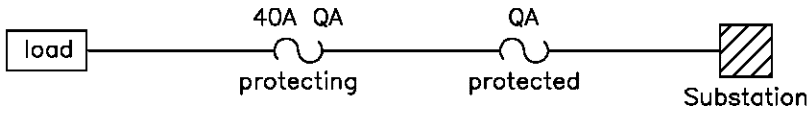
Protecting Fuse – refers to the fuse closest to the load with respect to the "protected" fuse.

EXPULSION PROTECTING FUSE COORDINATION TABLE

To insure that proper coordination is obtained between protecting and protected fuses, the following information is required:

1. The size and type of the protecting expulsion fuse, (e.g., 40 amp QA)
2. The type of protected sectionalizing fuse to be sized, (e.g., QA)
3. The maximum available fault current at the protecting fuse location.

Example:



Maximum available fault current at the 40 amp protecting fuse is – 3,100 amps.

The minimum size protected fuse required for coordination is a 125 amp QA (refer to page 6133.4).

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)												
		GE EJO–1 COMBINED TECHNOLOGIES EOD/SD								KEARNEY TYPE A				COOPER X–LIMITER
		30 (A)	40	50 (A)	65 (A)	80	100	150	200	30 (A)	40	50 (A)	65	140A
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
KEARNEY QA	5	250	300	450	750	1000	1300	2500	3000	200	300	760	1000	3800
	10 (2)	70	100	220	550	975	1300	2500	3000	110	160	640	900	3800
	15	–	95	200	500	910	1250	2420	3000	100	150	630	890	3800
	20	–	85	140	250	710	1100	2400	3000	80	130	550	800	3800
	25	–	–	130	200	500	980	2300	2900	75	120	500	700	3800
	30	–	–	120	180	270	800	2100	2800	70	100	450	600	3800
	40	–	–	–	160	230	450	2000	2500	–	90	350	500	3700
	50	–	–	–	–	200	350	1750	2400	–	–	300	430	3600
	60	–	–	–	–	190	300	1300	2000	–	–	250	350	3400
	75	–	–	–	–	–	260	610	1100	–	–	–	300	2800
	100	–	–	–	–	–	–	510	800	–	–	–	–	2300
	125	–	–	–	–	–	–	450	700	–	–	–	–	1700
	150	–	–	–	–	–	–	–	600	–	–	–	–	250
S&C SM–4	10	70	110	200	320	600	820	1700	2000	110	150	520	700	*
	15	60	90	140	250	500	800	1600	2000	90	130	500	620	*
	30	–	80	120	170	230	400	1500	1800	–	–	350	450	*
	40	–	–	110	160	220	360	1400	1600	–	–	320	430	*
	50	–	–	–	150	200	320	1100	1400	–	–	–	370	*
	65	–	–	–	–	–	270	700	900	–	–	–	–	*
	80	–	–	–	–	–	–	560	700	–	–	–	–	*
	100	–	–	–	–	–	–	500	600	–	–	–	–	*
	125	–	–	–	–	–	–	–	500	–	–	–	–	*
	150	–	–	–	–	–	–	–	–	–	–	–	–	*
	200	–	–	–	–	–	–	–	–	–	–	–	–	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f,

– Will not coordinate for any I_f.

(2) Kearney type 200

(A) No longer purchased.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		S&C SM-4											KEARNEY TYPE B		
		10	15	30	40	50	65	80	100	125	150	200	30	80	150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
KEARNEY QA	5	280	500	1100	1400	1500	2300	2700	3500	4500	5500	8000	340	860	1800
	10②	–	–	850	1300	1500	2300	2700	3500	4500	5500	8000	260	800	1800
	15	–	65	950	1300	1500	2300	2700	3500	4500	5500	8000	260	800	1750
	20	–	–	700	1100	1400	2200	2600	3500	4500	5500	8000	230	740	1750
	25	–	–	510	900	1300	2100	2600	3500	4500	5500	8000	220	680	1700
	30	–	–	–	700	1200	2000	2600	3500	4500	5500	8000	200	640	1600
	40	–	–	–	–	800	1900	2500	3400	4500	5500	8000	–	560	1500
	50	–	–	–	–	–	1500	2200	3400	4500	5500	8000	–	400	1450
	60	–	–	–	–	–	300	1600	3300	4000	5200	7900	–	240	1350
	75	–	–	–	–	–	–	220	2700	3500	4900	7300	–	170	1050
	100	–	–	–	–	–	–	–	1300	2000	4000	6800	–	–	640
	125	–	–	–	–	–	–	–	200	330	2300	6000	–	–	440
	150	–	–	–	–	–	–	–	–	–	–	4500	–	–	–
S&C SM-4	10	–	150	600	760	1000	1500	2000	2500	3300	4000	6100	250	700	1500
	15	–	–	470	700	900	1400	1800	2300	3300	4000	6100	220	640	1400
	30	–	–	–	120	420	1100	1500	2200	3300	4000	6000	180	470	1350
	40	–	–	–	–	180	900	1400	2100	3000	4000	6000	–	360	1300
	50	–	–	–	–	–	390	1100	1800	2900	3900	5800	–	250	1300
	65	–	–	–	–	–	–	230	1100	2400	3900	5300	–	–	1000
	80	–	–	–	–	–	–	–	280	1900	3200	5100	–	–	700
	100	–	–	–	–	–	–	–	–	540	2300	4700	–	–	500
	125	–	–	–	–	–	–	–	–	–	450	3400	–	–	–
	150	–	–	–	–	–	–	–	–	–	–	1900	–	–	–
	200	–	–	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

② Kearney type 200.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		KEARNEY QA													RTE
		10	15	20	25	30	40	50	60	75	100	125	150	200	150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
KEARNEY QA	5	180	290	500	600	800	1000	1300	1500	2200	2800	3500	4500	7000	2500
	10(2)	–	–	90	350	540	810	1250	1500	2200	2800	3500	4500	7000	2500
	15	–	–	70	260	500	800	1200	1500	2200	2800	3500	4500	7000	2400
	20	–	–	–	–	140	550	900	1300	2100	2800	3500	4500	7000	2300
	25	–	–	–	–	50	300	750	1200	2000	2700	3500	4500	7000	2300
	30	–	–	–	–	–	85	450	950	1800	2600	3500	4500	7000	2200
	40	–	–	–	–	–	–	70	550	1600	2400	3300	4400	7000	2050
	50	–	–	–	–	–	–	–	–	1300	2200	3000	4100	7000	1900
	60	–	–	–	–	–	–	–	–	150	1600	2600	3900	6700	1600
	75	–	–	–	–	–	–	–	–	–	200	1400	3000	6200	1100
	100	–	–	–	–	–	–	–	–	–	–	210	1900	5500	800
	125	–	–	–	–	–	–	–	–	–	–	–	–	4000	600
	150	–	–	–	–	–	–	–	–	–	–	–	–	3300	–
S&C SM–4	10	–	–	110	220	330	480	660	880	1350	1850	2400	3200	5000	1700
	15	–	–	–	–	160	400	620	850	1350	1850	2400	3200	5000	1650
	30	–	–	–	–	–	–	–	350	1050	1600	2250	3000	5000	1600
	40	–	–	–	–	–	–	–	–	800	1400	2100	2900	4900	1500
	50	–	–	–	–	–	–	–	–	–	1150	1900	2800	4800	1350
	65	–	–	–	–	–	–	–	–	–	–	1300	2400	4500	1050
	80	–	–	–	–	–	–	–	–	–	–	–	1900	4100	890
	100	–	–	–	–	–	–	–	–	–	–	–	–	3500	–
	125	–	–	–	–	–	–	–	–	–	–	–	–	1800	–
	150	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	200	–	–	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

(2) Kearney type 200.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)											
		McGRAW–EDISON/COOPER NX								ELASTIMOLD FUSED ELBOW		COPPER ELF	
		8	10	12	18	20	25	30	40	18 (A)	30	30	65
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION											
KEARNEY QA	5	32	70	150	240	300	350	580	800	350	700	*	*
	10 (2)	–	–	50	140	190	250	470	750	250	650	*	*
	15	–		45	130	170	220	430	690	220	600	*	*
	20	–	–	–	110	140	190	370	590	170	500	*	*
	25	–	–	–	100	130	160	330	500	140	400	*	*
	30	–	–	–	–	–	150	290	460	–	270	*	*
	40	–	–	–	–	–	–	250	400	–	220	–	*
	50	–	–	–	–	–	–	–	350	–	–	–	*
	60	–	–	–	–	–	–	–	–	–	–	–	*
	75	–	–	–	–	–	–	–	–	–	–	–	–
	100	–	–	–	–	–	–	–	–	–	–	–	–
	125	–	–	–	–	–	–	–	–	–	–	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–
S&C SM–4	10	–	–	54	150	180	230	400	580	240	500	520	1400
	15	–	–	–	120	150	200	320	520	190	450	450	1200
	30	–	–	–	–	–	–	–	430	–	–	–	900
	40	–	–	–	–	–	–	–	–	–	–	–	880
	50	–	–	–	–	–	–	–	–	–	–	–	–
	65	–	–	–	–	–	–	–	–	–	–	–	–
	80	–	–	–	–	–	–	–	–	–	–	–	–
	100	–	–	–	–	–	–	–	–	–	–	–	–
	125	–	–	–	–	–	–	–	–	–	–	–	–
	150	–	–	–	–	–	–	–	–	–	–	–	–
	200	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

(2) Kearney type 200.

(A) Not being ordered

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)											
		GE EJO–1 COMBINED TECHNOLOGIES EOD/SD								KEARNEY TYPE A			
		30	40	50	65	80	100	150	200	30	40	50	65
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION											
GE D&W (at 4kV)	6	*	*	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*	*	*
	15	*	*	*	*	*	*	*	*	*	*	*	*
	20	*	*	*	*	*	*	*	*	*	*	*	*
	25	180	*	*	*	*	*	*	*	190	*	*	*
	30	90	190	*	*	*	*	*	*	140	230	*	*
	40	70	120	300	*	*	*	*	*	120	170	*	*
	50	–	95	170	500	*	*	*	*	95	140	670	*
	65	–	–	140	250	600	1500	*	*	80	130	500	710
	75	–	–	–	180	260	620	*	*	–	110	400	600
	100	–	–	–	170	250	440	2000	*	–	100	370	500
	125	–	–	–	–	210	370	1600	*	–	–	330	450
	150	–	–	–	–	–	300	900	2200	–	–	250	340

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		S&C SM-4											KEARNEY TYPE B		
		10	15	30	40	50	65	80	100	125	150	200	30	80	150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
GE D&W (at 4kV)	6	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	15	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	20	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	25	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	30	–	*	*	*	*	*	*	*	*	*	*	330	*	*
	40	–	270	*	*	*	*	*	*	*	*	*	270	*	*
	50	–	–	*	*	*	*	*	*	*	*	*	250	850	*
	65	–	–	600	1100	*	*	*	*	*	*	*	230	700	*
	75	–	–	–	440	1000	*	*	*	*	*	*	190	650	1700
	100	–	–	–	200	560	1500	*	*	*	*	*	180	500	1500
	125	–	–	–	–	200	1200	2100	*	*	*	*	170	440	1400
	150	–	–	–	–	–	150	1000	8000	*	*	*	–	200	1300

NOTES:

1. Protecting fuse is on 4kV and protected fuses on 12kV.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES) AT 12KV													
		KEARNEY QA												RTE	COOPER X–LIMITER
		10 (2)	15	20	25	30	40	50	60	75	100	125	150	150	140
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION (at 12kV)													
GE D&W (at 4kV)	6	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	15	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	20	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	25	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	30	120	–	*	*	*	*	*	*	*	*	*	*	*	*
	40	–	–	250	*	*	*	*	*	*	*	*	*	*	*
	50	–	–	–	–	450	*	*	*	*	*	*	*	*	*
	65	–	–	–	–	–	430	*	*	*	*	*	*	2600	*
	75	–	–	–	–	–	–	300	*	*	*	*	*	1800	*
	100	–	–	–	–	–	–	110	*	*	*	*	*	1400	*
	125	–	–	–	–	–	–	–	–	1000	*	*	*	1250	*
	150	–	–	–	–	–	–	–	–	–	1100	*	*	850	4300

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

(2) Kearney type 200

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)											
		McGRAW–EDISON/COOPER NX								ELASTIMOLD FUSED ELBOW		COOPER ELF	
		8	10	12	18	20	25	30	40	18	30	30	65
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION											
GE D&W (at 4kV)	6	100	*	*	*	*	*	*	*	*	*	*	*
	10	50	*	*	*	*	*	*	*	*	*	*	*
	15	35	140	*	*	*	*	*	*	*	*	*	*
	20	30	70	*	*	*	*	*	*	*	*	*	*
	25	25	40	120	250	*	*	*	*	*	*	*	*
	30	–	–	60	180	250	350	*	*	340	*	*	*
	40	–	–	50	150	200	280	600	*	270	*	800	*
	50	–	–	–	140	160	220	450	*	230	680	600	*
	65	–	–	–	120	150	200	360	590	180	470	500	1400
	75	–	–	–	–	–	150	300	490	–	280	–	1200
	100	–	–	–	–	–	–	290	450	_	260	–	1000
	125	–	–	–	–	–	–	–	400	_	_	_	900
	150	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

TABLE OF CONTENTS

QA PROTECTING FUSE LINK RATING (Amperes) (at 4kV)	QA Protected Fuse Link Rating (Amperes) 12kV										
	15	20	25	30	40	50	60	75	100	125	150
	I_f, Maximum R.M.S. Amperes for Safe Coordination (at 12kV)										
10 (2)	325	500	620	780	1000	1250	1500	2200	2900	3500	4500
15	320	500	620	760	980	1200	1500	2200	2800	3500	4400
20	220	440	570	720	920	1200	1500	2200	2800	3500	4400
25	130	400	540	700	920	1200	1500	2200	2800	3500	4400
30	–	320	490	640	880	1200	1500	2200	2800	3500	4400
40	–	80	370	560	820	1150	1450	2200	2800	3500	4400
50	–	–	70	470	760	1100	1450	2200	2800	3500	4400
60	–	–	–	90	600	980	1300	2100	2700	3500	4400
75	–	–	–	–	100	550	1000	1900	2600	3400	4400
100	–	–	–	–	–	90	600	1600	2350	3200	4200
125	–	–	–	–	–	–	110	1200	2100	3000	4100
150	–	–	–	–	–	–	–	130	1700	2600	3800

NOTES:

1. Protecting QA fuse is on 4kV and protected QA fuse is on 12kV.

– Will not coordinate for any I_f.

(2) Kearney type 200.

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PROTECTED FUSE TYPE & LINK RATING (AMPERES) (AT 4KV)												
GE D&W Protecting Fuse Link Rating (Amperes) (at 4kV)	RTE SD	S&C SM–4										
	150	10	15	30	40	50	65	80	100	125	150	200
	I_f, MAX. RMS AMPS FOR SAFE COORDINATION											
6	2600	*	*	*	*	*	*	*	*	*	*	*
10	2600	*	*	*	*	*	*	*	*	*	*	*
15	2600	260	*	*	*	*	*	*	*	*	*	*
20	2600	–	*	*	*	*	*	*	*	*	*	*
25	2600	–	–	*	*	*	*	*	*	*	*	*
30	2600	–	–	*	*	*	*	*	*	*	*	*
40	2600	–	–	600	*	*	*	*	*	*	*	*
50	2300	–	–	–	–	1300	*	*	*	*	*	*
65	1400	–	–	–	–	–	1400	2750	*	*	*	*
75	1000	–	–	–	–	–	–	720	2600	*	*	*
100	870	–	–	–	–	–	–	–	1500	3600	7200	*
125	–	–	–	–	–	–	–	–	–	2900	7000	*
150	–	–	–	–	–	–	–	–	–	–	–	*

NOTES:

1. Both protecting and protected fuses are 4kV.

– Will not coordinate for any I_f.

TABLE OF CONTENTS

GE D&W Protecting Fuse Link Rating (Amperes) (at 4kV)	QA Protected Fuse Link Rating at 4kV (Amperes)											
	10 (2)	15	20	25	30	40	50	60	75	100	125	150
	I_f, Maximum R.M.S. Amperes for Safe Coordination											
6	350	630	530	650	770	980	1250	1550	2250	2800	3600	4400
10	130	610	530	650	770	980	1250	1550	2250	2800	3600	4400
15	–	–	400	650	770	980	1250	1550	2250	2800	3600	4400
20	–	–	–	–	770	980	1250	1550	2250	2800	3600	4400
25	–	–	–	–	–	980	1250	1550	2250	2800	3600	4400
30	–	–	–	–	–	–	900	1550	2250	2800	3600	4400
40	–	–	–	–	–	–	–	800	2250	2800	3600	4400
50	–	–	–	–	–	–	–	–	1300	2800	3600	4400
65	–	–	–	–	–	–	–	–	–	1200	2800	4400
75	–	–	–	–	–	–	–	–	–	–	600	2900
100	–	–	–	–	–	–	–	–	–	–	–	1500
125	–	–	–	–	–	–	–	–	–	–	–	–
150	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

– Will not coordinate at any I_f.

(2) Kearney type 200.

TABLE OF CONTENTS

GE D&W Protecting Fuse Link Rating (Amperes) (at 4kV)	QA Protected Fuse Link Rating at 4kV (Amperes)												
	6	10	15	20	25	30	40	50	65	75	100	125	150
	I_f, Maximum R.M.S. Amperes for Safe Coordination												
6	–	23	90	230	*	*	*	*	*	*	*	*	*
10	–	–	29	100	450	*	*	*	*	*	*	*	*
15	–	–	–	45	200	*	*	*	*	*	*	*	*
20	–	–	–	–	60	400	*	*	*	*	*	*	*
25	–	–	–	–	–	–	420	*	*	*	*	*	*
30	–	–	–	–	–	–	–	520	*	*	*	*	*
40	–	–	–	–	–	–	–	–	590	*	*	*	*
50	–	–	–	–	–	–	–	–	–	*	*	*	*
65	–	–	–	–	–	–	–	–	–	200	700	1700	5000
75	–	–	–	–	–	–	–	–	–	–	–	500	2000
100	–	–	–	–	–	–	–	–	–	–	–	–	1500
125	–	–	–	–	–	–	–	–	–	–	–	–	900
150	–	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

– Will not coordinate at any I_f.

(2) Kearney type 200.

TABLE OF CONTENTS

GE D&W Protecting Fuse Link Rating (Amperes) (at 4kV)	GE D&W Protected Fuse Type & Link Rating at 4kV (Amperes)														
	6	10	15	20	25	30	40	50	65	75	100	125	140	150	200
	I_f, Maximum R.M.S. Amperes for Safe Coordination														
6	–	75	180	*	*	*	*	*	*	*	*	*	*	*	*
10	–	–	55	170	*	*	*	*	*	*	*	*	*	*	*
15	–	–	–	70	*	*	*	*	*	*	*	*	*	*	*
20	–	–	–	–	180	*	*	*	*	*	*	*	*	*	*
25	–	–	–	–	–	–	1000	*	*	*	*	*	*	*	*
30	–	–	–	–	–	–	–	*	*	*	*	*	*	*	*
40	–	–	–	–	–	–	–	250	*	*	*	*	*	*	*
50	–	–	–	–	–	–	–	–	–	*	*	*	*	*	*
65	–	–	–	–	–	–	–	–	–	700	*	*	*	*	*
75	–	–	–	–	–	–	–	–	–	–	–	900	5000	*	*
100	–	–	–	–	–	–	–	–	–	–	–	500	1500	2500	*
125	–	–	–	–	–	–	–	–	–	–	–	–	800	1300	4600
140	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3000
150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
200	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

– Will not coordinate for any I_f.

* Will coordinate for all I_f.

TABLE OF CONTENTS

PROTECTING FUSE TYPE LINK RATING (AMPERES)		MVI QA PROTECTED FUSE TYPE (AMPERES)								
		20	30	40	50	65	80	100	125	150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
GE EJO–1 COMBINED TECHNOLOGIES EOD/SD	30	–	–	*	*	*	*	*	*	*
	40	–	–	–	–	*	*	*	*	*
	50	–	–	–	–	*	*	*	*	*
	65	–	–	–	–	–	–	*	*	*
	80	–	–	–	–	–	–	–	*	*
	100	–	–	–	–	–	–	–	–	–
	150	–	–	–	–	–	–	–	–	–
	200	–	–	–	–	–	–	–	–	–
MCGRAW–EDISON COOPER NX	8	*	*	*	*	*	*	*	*	*
	10	–	*	*	*	*	*	*	*	*
	12	–	*	*	*	*	*	*	*	*
	18	–	–	–	*	*	*	*	*	*
	20	–	–	–	–	*	*	*	*	*
	25	–	–	–	–	*	*	*	*	*
	30	–	–	–	–	–	–	*	*	*
	40	–	–	–	–	–	–	–	*	*
ELASTIMOLD FUSED ELBOW	18	–	*	*	*	*	*	*	*	*
	30	–	–	–	–	*	*	*	*	*
COOPER ELF	30	–	–	–	–	*	*	*	*	*
	65	–	–	–	–	–	–	–	*	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI QA PROTECTING FUSE LINK (AMPERES)	MVI QA PROTECTED FUSE TYPE (AMPERES)								
	20	30	40	50	65	80	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
20	–	*	*	*	*	*	*	*	*
30	–	–	–	*	*	*	*	*	*
40	–	–	–	–	*	*	*	*	*
50	–	–	–	–	–	*	*	*	*
65	–	–	–	–	–	800	*	*	*
80	–	–	–	–	–	–	1000	*	*
100	–	–	–	–	–	–	–	1800	*
125	–	–	–	–	–	–	–	–	1600
150	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

MVI QA PROTECTING (AT 4KV) (AMPERES)	MVI QA PROTECTED FUSE TYPE 12KV (AMPERES)								
	20	30	40	50	65	80	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
15	950	1380	1900	2360	3100	3700	4750	6500	7800
20	950	1380	1900	2360	3100	3700	4750	6500	7800
25	950	1380	1900	2360	3100	3700	4750	6500	7800
30	950	1380	1900	2360	3100	3700	4750	6500	7800
40	950	1380	1900	2360	3100	3700	4750	6500	7800
50	760	1380	1900	2360	3100	3700	4750	6500	7800
60	–	1380	1900	2360	3100	3700	4750	6500	7800
75	–	990	1800	2360	3100	3700	4750	6500	7800
100	–	–	1350	2250	3100	3700	4750	6500	7800
125	–	–	–	1450	3000	3500	4750	6500	7800
150	–	–	–	–	2500	3550	4750	6500	7800

NOTES:

1. Protecting fuse is on 4kv and protected fuses are on 12kv.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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QA PROTECTING FUSE LINK (AMPERES)	MVI QA PROTECTED FUSE CURVE TYPE (AMPERES)								
	20	30	40	50	65	80	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
15	290	460	620	770	990	1235	1535	2080	2560
20	–	440	620	770	990	1235	1535	2080	2560
25	–	340	620	770	990	1235	1535	2080	2560
30	–	–	545	770	990	1235	1535	2080	2560
40	–	–	–	645	990	1235	1535	2080	2560
50	–	–	–	–	930	1235	1535	2080	2560
60	–	–	–	–	550	1135	1535	2080	2560
75	–	–	–	–	–	–	1315	2080	2560
100	–	–	–	–	–	–	–	1875	2560
125	–	–	–	–	–	–	–	–	1975
150	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses/devices are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

QA PROTECTING FUSE LINK (at 4kV (AMPERES)	MVI QA PROTECTED FUSE CURVE TYPE 12 kV (AMPERES)								
	20	30	40	50	65	80	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
15	950	1380	1900	2360	3100	3700	4750	6500	7800
20	950	1380	1900	2360	3100	3700	4750	6500	7800
25	950	1380	1900	2360	3100	3700	4750	6500	7800
30	950	1380	1900	2360	3100	3700	4750	6500	7800
40	950	1380	1900	2360	3100	3700	4750	6500	7800
50	760	1380	1900	2360	3100	3700	4750	6500	7800
60	–	1380	1900	2360	3100	3700	4750	6500	7800
75	–	990	1800	2360	3100	3700	4750	6500	7800
100	–	–	1350	2250	3100	3700	4750	6500	7800
125	–	–	–	1450	3000	3500	4750	6500	7800
150	–	–	–	–	2500	3550	4750	6500	7800

NOTES:

1. Protecting fuse/device is on 4kV and protected fuse/device is on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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MVI QA PROTECTING FUSE CURVE LINK (AMPERES) (AT 4KV)	MVI QA PROTECTED FUSE CURVE TYPE 12KV (AMPERES)								
	20	30	40	50	65	80	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
20	*	*	*	*	*	*	*	*	*
30	*	*	*	*	*	*	*	*	*
40	*	*	*	*	*	*	*	*	*
50	640	*	*	*	*	*	*	*	*
65	–	1250	*	*	*	*	*	*	*
80	–	650	*	*	*	*	*	*	*
100	–	–	1200	*	*	*	*	*	*
125	–	–	–	800	*	*	*	*	*
150	–	–	–	–	1800	*	*	*	*

NOTES:

1. Protecting fuse/device is on 4kV and protected fuse/device are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

MVI QA PROTECTING FUSE CURVE LINK (AMPERES)	QA PROTECTED FUSE CURVE TYPE (AMPERES)										
	15	20	25	30	40	50	60	75	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION										
20	–	–	–	–	595	745	950	1330	1690	2170	2730
30	–	–	–	–	–	745	950	1330	1690	2170	2730
40	–	–	–	–	–	–	–	1330	1690	2170	2730
50	–	–	–	–	–	–	–	–	1690	2170	2730
65	–	–	–	–	–	–	–	–	–	2170	2730
80	–	–	–	–	–	–	–	–	–	–	2730
100	–	–	–	–	–	–	–	–	–	–	–
125	–	–	–	–	–	–	–	–	–	–	–
150	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses/devices are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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MVI QA PROTECTING FUSE LINK (AMPERES) (at 4kV)	QA PROTECTED FUSE TYPE 12kV (AMPERES)										
	15	20	25	30	40	50	60	75	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION										
20	640	910	1100	1375	1750	2150	2700	3800	4850	6300	8000
30	–	910	1100	1375	1750	2150	2700	3800	4850	6300	8000
40	–	–	1100	1375	1750	2150	2700	3800	4850	6300	8000
50	–	–	–	1375	1750	2150	2700	3800	4850	6300	8000
65	–	–	–	–	1750	2150	2700	3800	4850	6300	8000
80	–	–	–	–	–	2150	2700	3800	4850	6300	8000
100	–	–	–	–	–	–	2700	3800	4850	6300	8000
125	–	–	–	–	–	–	–	3800	4850	6300	8000
150	–	–	–	–	–	–	–	–	4850	6300	8000

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI QA PROTECTING FUSE LINK (AMPERES)	GE EJO-1 PROTECTED FUSE LINK RATING (AMPERES)								COOPER X–LIMITER
	30	40	50	65	80	100	150	200	140
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
20	–	90	145	310	640	840	1490	1895	1950
30	–	–	115	190	325	840	1490	1895	1950
40	–	–	–	165	230	430	1490	1895	1950
50	–	–	–	155	210	345	1490	1895	1950
65	–	–	–	–	195	290	1490	1895	1950
80	–	–	–	–	–	270	690	1895	1950
100	–	–	–	–	–	–	545	975	1320
125	–	–	–	–	–	–	475	750	–
150	–	–	–	–	–	–	–	655	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI QA PROTECTING FUSE LINK (AMPERES)	S & C SM-4 PROTECTED FUSE LINK RATING (AMPERES)											RTE	COOPER ELF	
	10	15	30	40	50	65	80	100	125	150	200	150	30	65
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
20	–	–	670	805	970	1350	1620	2020	2675	3260	3965	870	405	1000
30	–	–	240	805	970	1350	1620	2020	2675	3260	3965	870	–	1000
40	–	–	–	–	970	1350	1620	2020	2675	3260	3965	700	–	1000
50	–	–	–	–	–	1350	1620	2020	2675	3260	3965	495	–	850
65	–	–	–	–	–	–	1620	2020	2675	3260	3965	400	–	–
80	–	–	–	–	–	–	–	2020	2675	3260	3965	350	–	–
100	–	–	–	–	–	–	–	–	2675	3260	3965	315	–	–
125	–	–	–	–	–	–	–	–	–	3260	3965	–	–	–
150	–	–	–	–	–	–	–	–	–	–	3965	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI QA PROTECTING FUSE LINK (AMPERES)	COPPER NX PROTECTED FUSE LINK RATING (AMPERES)								ELASTIMOLD FUSED ELBOW	
	8	10	12	18	20	25	30	40	18	30
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
20	–	–	–	–	–	210	405	615	–	600
30	–	–	–	–	–	–	325	525	–	–
40	–	–	–	–	–	–	–	435	–	–
50	–	–	–	–	–	–	–	–	–	–
65	–	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–	–
100	–	–	–	–	–	–	–	–	–	–
125	–	–	–	–	–	–	–	–	–	–
150	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f.

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	MVI D & W PROTECTED FUSE TYPE 4kV (AMPERES)								
	30	40	50	65	75	100	125	150	200
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
30	–	*	*	*	*	*	*	*	*
40	–	–	*	*	*	*	*	*	*
50	–	–	–	*	*	*	*	*	*
65	–	–	–	–	*	*	*	*	*
75	–	–	–	–	–	*	*	*	*
100	–	–	–	–	–	–	*	*	*
125	–	–	–	–	–	–	–	*	*
150	–	–	–	–	–	–	–	–	*
200	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	MVI D & W PROTECTED FUSE TYPE 12kV (AMPERES)								
	30	40	50	65	75	100	125	150	200
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION								
30	*	*	*	*	*	*	*	*	*
40	*	*	*	*	*	*	*	*	*
50	*	*	*	*	*	*	*	*	*
65	*	*	*	*	*	*	*	*	*
75	–	*	*	*	*	*	*	*	*
100	–	–	*	*	*	*	*	*	*
125	–	–	*	*	*	*	*	*	*
150	–	–	–	–	*	*	*	*	*
200	–	–	–	–	*	*	*	*	*

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	GE D & W PROTECTED FUSE TYPE 4kV (AMPERES)												
	10	15	20	25	30	40	50	65	75	100	125	150	200
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
30	–	–	–	–	–	–	705	950	1325	1500	1940	2790	3900
40	–	–	–	–	–	–	300	950	1325	1500	1940	2790	3900
50	–	–	–	–	–	–	–	–	1325	1500	1940	2790	3900
65	–	–	–	–	–	–	–	–	910	1500	1940	2790	3900
75	–	–	–	–	–	–	–	–	–	–	1010	2790	3900
100	–	–	–	–	–	–	–	–	–	–	625	2790	3900
125	–	–	–	–	–	–	–	–	–	–	–	1900	3900
150	–	–	–	–	–	–	–	–	–	–	–	–	–
200	–	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	GE D & W PROTECTED FUSE TYPE 12kV (AMPERES)												
	10	15	20	25	30	40	50	65	75	100	125	150	200
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
30	–	–	420	800	1125	1500	2000	2800	4000	4500	5800	8500	11500
40	–	–	–	800	1125	1500	2000	2800	4000	4500	5800	8500	11500
50	–	–	–	175	1125	1500	2000	2800	4000	4500	5800	8500	11500
65	–	–	–	–	230	1230	2000	2800	4000	4500	5800	8500	11500
75	–	–	–	–	–	–	1500	2800	4000	4500	5800	8500	11500
100	–	–	–	–	–	–	950	2800	4000	4500	5800	8500	11500
125	–	–	–	–	–	–	–	1800	4000	4500	5800	8500	11500
150	–	–	–	–	–	–	–	–	3400	4500	5800	8500	11500
200	–	–	–	–	–	–	–	–	–	950	5800	8500	11500

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	QA PROTECTED FUSE LINK RATING 4kV (AMPERES)										
	15	20	25	30	40	50	60	75	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION										
30	–	–	–	–	–	730	915	1300	1700	2140	2700
40	–	–	–	–	–	–	915	1300	1700	2140	2700
50	–	–	–	–	–	–	–	1300	1700	2140	2700
65	–	–	–	–	–	–	–	–	1700	2140	2700
75	–	–	–	–	–	–	–	–	–	1450	2700
100	–	–	–	–	–	–	–	–	–	–	2350
125	–	–	–	–	–	–	–	–	–	–	–
150	–	–	–	–	–	–	–	–	–	–	–
200	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting protected fuses are on 4kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	QA PROTECTED FUSE LINK RATING AT 12kV (AMPERES)										
	15	20	25	30	40	50	60	75	100	125	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION										
30	–	950	1150	1400	1750	2200	2750	3900	5000	6300	8000
40	–	950	1150	1400	1750	2200	2750	3900	5000	6300	8000
50	–	–	–	1400	1750	2200	2750	3900	5000	6300	8000
65	–	–	–	1025	1750	2200	2750	3900	5000	6300	8000
75	–	–	–	–	–	2200	2750	3900	5000	6300	8000
100	–	–	–	–	–	1050	2750	3900	5000	6300	8000
125	–	–	–	–	–	–	–	3900	5000	6300	8000
150	–	–	–	–	–	–	–	–	5000	6300	8000
200	–	–	–	–	–	–	–	–	–	6300	8000

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	S&C SM–4 PROTECTED FUSE LINK RATING AT 4kV (AMPERES)											RTE
	10	15	30	40	50	65	80	100	125	150	200	150
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION											
30	–	–	670	805	970	1350	1620	2020	2675	3260	3965	870
40	–	–	–	805	970	1350	1620	2020	2675	3260	3965	870
50	–	–	–	–	–	1350	1620	2020	2675	3260	3965	550
65	–	–	–	–	–	–	1620	2020	2675	3260	3965	425
75	–	–	–	–	–	–	–	1350	2675	3260	3965	–
100	–	–	–	–	–	–	–	–	2300	3260	3965	–
125	–	–	–	–	–	–	–	–	–	3260	3965	–
150	–	–	–	–	–	–	–	–	–	–	2950	–
200	–	–	–	–	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

MVI needs a minimum 15A current to operate.

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	S&C SM–4 PROTECTED FUSE LINK RATING AT 12kV (AMPERES)											RTE	COOPER X–LIMITER
	10	15	30	40	50	65	80	100	125	150	200	150	140
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
30	–	950	1950	2350	2800	4000	4700	6000	8000	9900	11800	2500	5800
40	–	950	1950	2350	2800	4000	4700	6000	8000	9900	11800	2500	5800
50	–	–	1950	2350	2800	4000	4700	6000	8000	9900	11800	2500	5800
65	–	–	1950	2350	2800	4000	4700	6000	8000	9900	11800	2500	5800
75	–	–	–	2350	2800	4000	4700	6000	8000	9900	11800	2500	5800
100	–	–	–	1520	2800	4000	4700	6000	8000	9900	11800	2240	5800
125	–	–	–	–	2200	4000	4700	6000	8000	9900	11800	1900	5800
150	–	–	–	–	–	3100	4700	6000	8000	9900	11800	1300	5800
200	–	–	–	–	–	–	–	6000	8000	9900	11800	1030	5800

NOTES:

1. Protecting fuse is on 4kV and protected fuses are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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MVI D & W PROTECTING FUSE LINK (AMPERES) (at 4kV)	GE EJO–1 PROTECTED FUSE LINK RATING AT 4kV (AMPERES)							
	30	40	50	65	80	100	150	200
	I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION							
30	–	–	120	225	640	840	1490	1895
40	–	–	–	175	280	840	1490	1895
50	–	–	–	–	215	370	1490	1895
65	–	–	–	–	–	295	1220	1895
75	–	–	–	–	–	–	640	1100
100	–	–	–	–	–	–	–	980
125	–	–	–	–	–	–	–	–
150	–	–	–	–	–	–	–	–
200	–	–	–	–	–	–	–	–

NOTES:

1. Both protecting and protected fuses are on 4kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)			
		S & C FAULT TAMER			
		5	10	15	20
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION			
S & C FAULT TAMER	5	–	240	300	300
	10	–	–	115	125
	15	–	–	–	–
	20	–	–	–	–

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)												
		KEARNY QA												
		5	10	15	20	25	30	40	50	60	75	100	125	150	200
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
S & C FAULT TAMER	5	–	140	225	380	485	610	*	*	*	*	*	*	*	*
	10	–	–	–	250	390	520	*	*	*	*	*	*	*	*
	15	–	–	–	–	–	470	670	*	*	*	*	*	*	*
	20	–	–	–	–	–	–	685	*	*	*	*	*	*	*

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)							
		McGRAW–EDISON/COOPER NX							
		8	10	12	18	20	25	30	40
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION							
S & C FAULT TAMER	5	–	–	130	215	265	315	500	735
	10	–	–	–	170	210	270	465	685
	15	–	–	–	145	185	245	445	660
	20	–	–	–	–	185	245	445	655

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)										
		S & C SM–4										
		10	15	30	40	50	65	80	100	125	150	200
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION										
S & C FAULT TAMER	5	220	395	*	*	*	*	*	*	*	*	*
	10	–	270	*	*	*	*	*	*	*	*	*
	15	–	–	*	*	*	*	*	*	*	*	*
	20	–	–	*	*	*	*	*	*	*	*	*

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)							
		GE EJO–1							
		30	40	50	65	80	100	150	200
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION							
S & C FAULT TAMER	5	160	240	380	580	*	*	*	*
	10	–	135	270	500	*	*	*	*
	15	–	–	200	450	*	*	*	*
	20	–	–	200	445	*	*	*	*

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)	
		COOPER ELF	
		30	65
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION	
S & C FAULT TAMER	5	500	*
	10	460	*
	15	440	*
	20	440	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)	
		ELASTIMOLD FUSED ELBOW	
		18	30
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION	
S & C FAULT TAMER	5	320	685
	10	285	655
	15	–	645
	20	–	635

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)
		RTE
		150
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION
S & C FAULT TAMER	5	*
	10	*
	15	*
	20	*

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)
		COOPER X–LIMITER
		140
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION
S & C FAULT TAMER	5	*
	10	*
	15	*
	20	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)			
		S & C FAULT TAMER			
		5	10	15	20
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION			
McGRAW-EDISON COOPER NX	8	–	–	*	*
	10	–	–	–	350
	12	–	–	–	–
	18	–	–	–	–
	20	–	–	–	–
	25	–	–	–	–
	30	–	–	–	–
	40	–	–	–	–
KEARNY QA	5	55	240	300	300
	10	–	70	155	155
	15	–	–	70	75
	20	–	–	–	–
	25	–	–	–	–
	30	–	–	–	–
	40	–	–	–	–
	50	–	–	–	–
	60	–	–	–	–
	75	–	–	–	–
	100	–	–	–	–
	125	–	–	–	–
	150	–	–	–	–
	200	–	–	–	–

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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PROTECTING FUSE TYPE LINK RATING (AMPERES) 4kV		PROTECTED FUSE TYPE & LINK RATING (AMPERES) 12kV			
		S & C FAULT TAMER			
		5	10	15	20
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION			
S & C FAULT TAMER (at 4kV)	5	325	*	*	*
	10	160	*	*	*
	15	–	*	*	*
	20	–	*	*	*

PROTECTING FUSE TYPE LINK RATING (AMPERES) 4kV		PROTECTED FUSE TYPE & LINK RATING (AMPERES) 12kV												
		KEARNY QA												
		5	10	15	20	25	30	40	50	60	75	100	125	150	200
		I_f, MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION												
S & C FAULT TAMER (at 4kV)	5	150	650	*	*	*	*	*	*	*	*	*	*	*	*
	10	–	560	*	*	*	*	*	*	*	*	*	*	*	*
	15	–	520	*	*	*	*	*	*	*	*	*	*	*	*
	20	–	–	*	*	*	*	*	*	*	*	*	*	*	*

NOTES:

1. Protecting Fuse is on 4kV and protected fuse are on 12kV.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)									
		SMU-20									
		25	30	40	50	65	80	100	125	150	200
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
SMU-20	25	---	100	500	900	1400	1900	2400	3000	3900	4800
	30	---	---	400	800	1300	1800	2300	2900	3800	4800
	40	---	---	---	500	1200	1700	2200	2900	3700	4700
	50	---	---	---	---	900	1400	2100	2800	3600	4600
	65	---	---	---	---	---	800	1600	2100	3400	4400
	80	---	---	---	---	---	---	1100	2100	3100	4300
	100	---	---	---	---	---	---	---	1400	2700	3900
	125	---	---	---	---	---	---	---	---	1700	3500
	150	---	---	---	---	---	---	---	---	---	2400
	200	---	---	---	---	---	---	---	---	---	---

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		KEARNY QA													RTE
		(2) 10	15	20	25	30	40	50	60	75	100	125	150	200	150
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
SMU-20	25	---	---	---	---	---	200	500	800	1400	1900	2400	3200	4900	800
	30	---	---	---	---	---	---	300	800	1300	1700	2400	3100	4800	700
	40	---	---	---	---	---	---	---	400	1200	1700	2300	3000	4700	600
	50	---	---	---	---	---	---	---	---	800	1400	2200	3000	4700	500
	65	---	---	---	---	---	---	---	---	---	900	1700	2600	4400	300
	80	---	---	---	---	---	---	---	---	---	---	1100	2300	4300	300
	100	---	---	---	---	---	---	---	---	---	---	---	1700	3900	300
	125	---	---	---	---	---	---	---	---	---	---	---	---	3300	---
	150	---	---	---	---	---	---	---	---	---	---	---	---	2400	---
	200	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f .

– Will not coordinate for any I_f .

(2) Kearney type 200.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		S&C SM-4										KEARNEY TYPE B			
		10	15	30	40	50	65	80	100	125	150	200	30	80	150
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
SMU-20	25	---	---	200	600	900	1400	1800	2300	3100	3800	4700	200	680	1600
	30	---	---	---	500	800	1300	1700	2300	3000	3800	4700	180	680	1500
	40	---	---	---	---	500	1200	1600	2200	3000	3800	4900	---	630	1400
	50	---	---	---	---	---	900	1400	2000	3000	3700	4300	---	580	1200
	65	---	---	---	---	---	---	800	1500	2600	3400	4300	---	560	1000
	80	---	---	---	---	---	---	---	---	2200	3200	4200	---	520	700
	100	---	---	---	---	---	---	---	---	1600	2700	3800	---	480	400
	125	---	---	---	---	---	---	---	---	---	1700	3100	---	---	400
	150	---	---	---	---	---	---	---	---	---	---	2000	---	---	---
	200	---	---	---	---	---	---	---	---	---	---	---	---	---	---

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)													
		S&C SM-4										KEARNEY TYPE B			
		10	15	30	40	50	65	80	100	125	150	200	30	80	150
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION													
SMU-20	25	---	---	200	600	900	1400	1800	2300	3100	3800	4700	200	680	1600
	30	---	---	---	500	800	1300	1700	2300	3000	3800	4700	180	680	1500
	40	---	---	---	---	500	1200	1600	2200	3000	3800	4900	---	630	1400
	50	---	---	---	---	---	900	1400	2000	3000	3700	4300	---	580	1200
	65	---	---	---	---	---	---	800	1500	2600	3400	4300	---	560	1000
	80	---	---	---	---	---	---	---	---	2200	3200	4200	---	520	700
	100	---	---	---	---	---	---	---	---	1600	2700	3800	---	480	400
	125	---	---	---	---	---	---	---	---	---	1700	3100	---	---	400
	150	---	---	---	---	---	---	---	---	---	---	2000	---	---	---
	200	---	---	---	---	---	---	---	---	---	---	---	---	---	---

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

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	Indicates Latest Revision		Completely Revised	X	New Page		Information Removed

REVISION DATE 8–18–2014 APPD JCE / DW	SDG&E DISTRIBUTION DESIGN MANUAL	6133.46
	SMU–20 FUSE COORDINATION TABLES	

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)											
		McGraw-Edison/Cooper NX								Elastimold Fused Elbow		Cooper ELF	
		8	10	12	18	20	25	30	40	18	30	30	65
		If MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION											
SMU-20	25	----	----	----	----	----	180	320	500	----	500	----	900
	30	----	----	----	----	----	----	300	475	----	----	----	900
	40	----	----	----	----	----	----	----	420	----	----	----	850
	50	----	----	----	----	----	----	----	----	----	----	----	800
	65	----	----	----	----	----	----	----	----	----	----	----	700
	80	----	----	----	----	----	----	----	----	----	----	----	----
	100	----	----	----	----	----	----	----	----	----	----	----	----
	125	----	----	----	----	----	----	----	----	----	----	----	----
	150	----	----	----	----	----	----	----	----	----	----	----	----
	200	----	----	----	----	----	----	----	----	----	----	----	----

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NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)									
		SMU-20									
		25	30	40	50	65	80	100	125	150	200
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
KEARNY QA	5 (2)	700	800	1100	1300	1900	2200	2800	3500	4400	5600
	10 (2)	600	700	1000	1200	1800	2200	2800	3500	4400	5600
	15	600	700	1000	1200	1700	2300	2900	3600	4500	5500
	20	500	600	900	1100	1700	2200	2800	3500	4400	5500
	25	300	500	800	1100	1600	2200	2700	3500	4400	5500
	30	---	300	700	1000	1600	2100	2700	3400	4200	5400
	40	---	---	300	800	1400	2000	2600	3300	4400	5300
	50	---	---	---	400	1200	1800	2600	3300	4300	5300
	60	---	---	---	---	900	1600	2300	3200	4100	5100
	75	---	---	---	---	---	400	1800	2700	3700	4900
	100	---	---	---	---	---	---	800	2200	3400	4700
	125	---	---	---	---	---	---	---	600	2700	4000
	150	---	---	---	---	---	---	---	300	600	3300

PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)									
		SMU-20									
		25	30	40	50	65	80	100	125	150	200
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
S&C FAULT TIMER	5	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*
	15	*	*	*	*	*	*	*	*	*	*
	20	*	*	*	*	*	*	*	*	*	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

* Will coordinate for all I_f.

– Will not coordinate for any I_f.

(2) Kearney type 200.

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PROTECTING FUSE TYPE LINK RATING (AMPERES)		PROTECTED FUSE TYPE & LINK RATING (AMPERES)									
		SMU-20									
		25	30	40	50	65	80	100	125	150	200
		I_f MAXIMUM R.M.S. AMPERES FOR SAFE COORDINATION									
GE EJO-1 COMBINED TECHNOLOGIES EOD/SD	30	---	---	1000	1300	*	*	*	*	*	*
	40	---	---	---	1300	1800	*	*	*	*	*
	50	---	---	---	---	1700	2400	*	*	*	*
	65	---	---	---	---	---	---	2900	*	*	*
	80	---	---	---	---	---	---	2700	3700	3000	*
	100	---	---	---	---	---	---	---	3500	---	3900
	150	---	---	---	---	---	---	---	---	---	5100
	200	---	---	---	---	---	---	---	---	---	---
KEARNEY TYPE B	30	---	---	---	---	100	*	*	*	*	*
	80	---	---	---	---	---	---	---	250	400	*
	150	---	---	---	---	---	---	---	---	---	*
KEARNEY TYPE A	30	---	---	*	*	*	*	*	*	*	*
	40	---	---	---	100	*	*	*	*	*	*
	50	---	---	---	---	---	150	*	*	*	*
	65	---	---	---	---	---	---	200	*	*	*
McGRAW-EDISON/COOPER NX	8	*	*	*	*	*	*	*	*	*	*
	10	*	*	*	*	*	*	*	*	*	*
	12	50	*	*	*	*	*	*	*	*	*
	18	50	60	90	*	*	*	*	*	*	*
	20	50	60	80	*	*	*	*	*	*	*
	25	---	---	80	100	130	*	*	*	*	*
	30	---	---	---	95	130	*	*	*	*	*
	40	---	---	---	---	130	150	*	*	*	*
ELASTIMOLD FUSED ELBOW	18	40	*	*	*	*	*	*	*	*	*
	30	---	---	80	100	*	*	*	*	*	*
RTE	150	---	---	---	---	---	---	---	---	---	*
COOPER ELF	30	---	---	90	130	*	*	*	*	*	*
	65	---	---	---	---	---	170	250	*	*	*

NOTES:

1. Both protecting and protected fuses are at the same voltage level.

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The California Electrical Code requires the installation of service equipment with overcurrent protective devices with a short circuit current rating equal to, or not less than, the available fault current provided by the Utility, and when applicable, the contribution to fault current from customer's motor contribution.

SDG&E's maximum contribution to fault current is stated as follows:

1. Residential – Applicable to a single family residence or duplex as defined in Rule 1 (which may include a house meter for a total of 3 meters), multi–family residential service consisting of 3 or more dwelling units, or a mobile home. Also applicable to service used in common for residential purposes in a multi–family dwelling, on a single premises, whether separately metered or combined with service to an individual dwelling unit. The Utility's contribution to the available fault current at the point of connection of SDG&E's service conductors to the customer's facilities will not exceed the values listed in Table 1.

TABLE 1

Phase	Serving Voltage	Service Entrance Ampacity	Utility's Contribution to Fault Current Will Not Exceed
1Ø	120/240	225 amps or less	10,000 amps
1Ø	120/240	226 – 600 amps	22,000 amps
1Ø	120/208	200 amps or less	42,000 amps
*1Ø	120/240	800 amps	42,000 amps
3Ø	120/240	600 amps or less (See Note 4)	42,000 amps
3Ø	208Y/120	201 – 3000 amps or less	42,000 amps
3Ø	208Y/120	3001 – 4000 amps	65,000 amps

* Deviation required for 800 ampere, or above, single–phase service requests.

2. Non–Residential – Applicable to all non–residential occupancies such as, but not limited to, commercial, industrial, agricultural, governmental, educational institutions, hospitals, medical clinics, etc.. The Utility's contribution to the available fault current at the point of connection of SDG&E's service conductors to the customer's facilities will not exceed the values listed in Table 2.

TABLE 2

Phase	Serving Voltage	Service Entrance Ampacity	Utility's Contribution to Fault Current Will Not Exceed
1Ø	120/208	200 amps or less	42,000 amps
1Ø	120/240	400 amps or less	42,000 amps
1Ø	240/480	200 amps or less	10,000 amps
3Ø	120/240	600 amps or less (See Note 4)	42,000 amps
3Ø	208Y/120	3000 amps or less	42,000 amps
3Ø	208Y/120	3001 amps – 4000 amps	65,000 amps
3Ø	480	600 amps or less (See Note 5)	30,000 amps
3Ø	480Y/277	2000 amps or less	30,000 amps
3Ø	480Y/277	2001 amps – 3000 amps	45,000 amps
3Ø	480Y/277	3001 amps – 4000 amps	65,000 amps

3. SDG&E's available fault current for medium and high voltage services will be calculated on an individual basis and will be quoted for both the initial and ultimate three–phase, line to line, and line to ground fault current values.

4. Maximum service panel size alllowed to be served by a 120/240 volt, three–plase delta transformer installation, overhead or underground, is 600 amperes.

5. Maximum service panel size alllowed to be served by an overhead 480 volt, three–plase delta transformer installation is 600 amperes.

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7. Electric Distribution Standards will provide a detailed calculation for available fault current for service entrance ampacities not covered in items 1, 2, and 2 above. The following EQUATIONS can be used to calculate maximum available fault current by converting Z% (see Z% in tables below) substituting for Z. Select a transformer size, for the calculation, with a full load current greater than or equal to the service entrance ampacity. Underground Standard 3706 lists transformer full load currents. (Fault current values are directly proportional to the transformer size used in the calculation. Select the maximum transformer size applicable to a given situation)

3Ø EQUATION

$$I_F = \frac{kVA}{\sqrt{3}\ (kV)\ (Z_T)}$$

1Ø EQUATION

$$I_F = \frac{kVA}{(kV)\ (Z_T)}$$

WHERE:

I_F = Fault Current (in amperes)

kVA = Transformer nameplate rating

kV = Transformer secondary voltage, line to line (120/240v = 240v line to line = .24kV)

Z% = Transformer impedance. Convert to decimal form ($\frac{Z\%}{100}$) and substitute for Z_T to calculate maximum available fault current.

Z_T = Total system impedance.

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Transformer Impedances for Fault Calculation

Single Phase Transformers (Overhead or Underground)

kVA	R%	X%	Z%
25	0.73	0.95	1.2
50	0.95	1.53	1.8
75	0.95	1.53	1.8
100	0.95	1.53	1.8
167	1.06	1.81	2.1

Three Phase Transformers 208Y/120 or 240/120 (Delta)

kVA	R%	X%	Z%
75	0.41	1.23	1.3
150	0.41	1.23	1.3
225	0.39	1.55	1.6
300	0.48	2.15	2.2
500	0.58	3.45	3.5
750–1500	0.59	5.28	5.32

Three Phase Transformers 480Y/277

kVA	R%	X%	Z%
75	0.41	1.23	1.3
150	0.41	1.23	1.3
225	0.32	1.26	1.3
300	0.28	1.27	1.3
500	0.36	2.17	2.2
750–3000	0.59	5.28	5.32

Three Phase Transformers 2400/4160 Y/2400 2400/4160 Grd Y/2400

kVA	R%	X%	Z%
150	.78	4.56	4.63
225	.78	4.56	4.63
300	.78	4.56	4.63
500	.78	4.56	4.63
750–2500	.59	5.28	5.32

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Limiting Secondary Short Circuit Current For Residential Services

The following tables, applicable to single–phase transformer installations through 100 kVA, show minimum service length required according to conductor size.

Overhead Service

Triplex Conductor Size	Minimum Length Service Required To Limit ISC to 10,000 Amperes
#4 AL or #6 CU	19 ft
#2 AL or #4 CU	30 ft
#1/0 AL or #2 CU	45 ft
#3/0 AL	67 ft

Underground Service

Cable Size	Minimum Length Service Required To Limit ISC to 10,000 Amperes
#2	32 ft
#1/0	50 ft
#3/0	74 ft
350 kcmil	119 ft
500 kcmil	173 ft

(1) Where more than a single wire size separates the transformer from the customer's service equipment, and no segment in the combination of lengths is long enough to satisfy the table values, consult Electric Distribution Standards or Support.

(2) Minimum lengths are measured from the transformer secondary lugs to the point of connection with the customer's service equipment.

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SCOPE

This procedure defines the steps that Electric Distribution Planning personnel should follow to insure that a distribution circuit is adequately protected.

PURPOSE

This procedure is intended to supplement Design Standards 6111 and 6121.

SUGGESTED ANALYTICAL STEPS

A. Fault Detection

The protective device must "see" the fault current available at the furthest point in the device's zone–of–protection in order to detect a fault.

The minimum allowable short circuit current at the end of a protective device's zone–of–protection in order to detect a fault.

The minimum allowable short circuit current at the end of a protective device's zone–of–protection shall not be less than 2 or 3 times the protective device rating/setting to account for increased impedance due to trees, asphalt, extremely dry conditions, etc. These factors are known as sensitivity margins and are established as:

3 – GND FAULTS
2 – PHASE FAULTS

In addition to the sensitivity margins, the use of a grounding bank also reduces the available short circuit current seen by the substation relay. To account for this, subtract 100 amps from the available line–to–ground fault current that has been calculated for each grounding bank installed between the substation and the end of the relay's zone–of–protection.

Relay and Fuse Sensitivity Margin Review

1. Obtain the circuit relay settings (PHASE and GND) from the current "Relay Test Record" (attachment A) and compare the settings to those shown on the most recent "Relay Setting Change Notice".

2. Calculate the minimum short circuit current required to insure adequate protective device sensitivity margins as follows:

$$I_{fL-G,\ MIN} = 3 \times (\text{relay setting})_{GND}$$

$$I_{f3\emptyset,\ MIN} = 2 \times (\text{relay setting})_{PHASE}$$

$$I_{fL-G,\ MIN} = 3 \times (\text{fuse size})$$

3. Use the PTI/PSSU program "Short Circuit Analysis" to check the available end–of–line* short circuit current on feeder line segment and local distribution branches. The available short circuit current shall be equal to the line–to–neutral current obtained from RAP.

*refers to the available fault current at the furthest point on the circuit from the protective device (in its zone–of–protection).

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When there is insufficient end–of–line short circuit current to insure adequate protective device sensitivity margins (step A.2), the following alternatives are sugested. Protection Engineering should be consulted if none of the alternatives are desirable.

a. Sectionalizing fuses may be installed at the point where the short circuit current falls below the amount required to insure adequate relay sensitivity margin, thus limiting the zone–of–protection. The fuse should be sized as follows:

$$\text{fuse size, MAX} = 1/3 \times I_{fL-G,\ \text{END OF LINE}}$$

b. The relay settings may be lowered provided that coordination is maintained between the relay and sectionalizing fuses as described in section C – Protective Device Coordination. If this is the desired alternative, Protection Engineering approval should be requested by submitting a completed "Relay Setting Change Notice" along with confirmation that relay/fuse coordination is maintained.

c. The existing branch fuse size may be reduced when available end–of–line short circuit current falls below the amount required to insure adequate fuse sensitivity margin. This reduction is possible only if fuse/fuse coordination is maintained. The replacement fuse should be sized as follows:

$$\text{fuse size, MAX} = 1/3 \times I_{fL-G,\ \text{END OF LINE}}$$

d. A sub–branch fuse may be installed at the point on the branch where the short circuit current falls below the amount required to insure adequate fuse sensitivity margin for the branch fuse. This reduces the branch fuse's zone–of–protection and raises the available fault current that the branch fuse must detect.

e. The minimum line–to–ground short circuit current required to insure adequate protective device sensitivity margin may be reduced provided the circuit or branch being considered for reduced margin is an underground circuit or branch with a continuous neutral conductor tied solidly to the substation.

Example:

$I_{fL-G,\ \text{MIN}} = 2.5 \times (\text{relay setting})_{GND}$

$I_{fL-G,\ \text{MIN}} = 2.5 \times (\text{fuse size})$

Further, a current–limiting fuse may not protect an overhead line via an up cable pole unless the up cable pole QA fuse coordinates with the CLF.

B. Individual Distribution Circuit Reliability

Design Standards 6111 "Feeder Circuit Sectionalizing & Protection", 6112 "Service Restorer Application Criteria" and 6121 "Fuse Application Criteria" provide the basic principals necessary to achieve a reliable distribution circuit. Through the application of these standards it is anticipated that the reliability goals established for the Company will be met.

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Design standards listed above are intended to reduce the impact of a failure such that:

1. Failures originating on local distribution branches that are isolated by the substation breaker will not exceed one per year.

2. Failures originating on local distribution sub–branches that are isolated by a branch fuse will not exceed three per year.

Design Standard 6111 – Review

1. Use the PTI/PSSU program "Short Circuit Analysis" to determine feeder line segment's load and distance; check for existing switches:

   a. within the main feeder line segment, provided that

      50A $\leq$ load $\leq$ 100A and 2,600' $\leq$ distance $\leq$ 5,300'

   b. around the feeder split points, provided that

      50A $\leq$ load on each feeder line segment

2. Use an accurate circuit operating map; check for existing switches:

   a. around major critical customers

   b. at feeder cable poles

   c. around inaccessible geographic areas

Design Standard 6121 – Review

1. Use the circuit operating map; verify that:

   a. each local distribution cable pole is fused.

   b. fuses are installed around each inaccessible goegraphic area.

   c. fuse cabinets that are equipped with CLF(S) do not serve overhead lines that are not protected by QA fuses which coordinate with the CLF.

   d. each padmounted capacitor station is either fused with a 150A CLF or is not fused.

2. Using the circuit operating map and the circuit interruption data for the past 3 years; determine if fuses are installed:

   a. on each local distribution branch of at least 2000 feet.

   b. on each local distribution branch of at least 1200 feet (subject to environmental influences).

c. on each local distribution branch that experienced 3 or more outages in the past 3 years.

d. on each local distribution sub–branch of at least 10,000 feet.

e. on each local distribution sub–branch that experienced 3 or more outages in the past year.

C. Protective Device Coordination

1. Protection Engineering shall be reponsible for the coordination of primary metered customer–owned protective equipment with SDG&E protective equipment. Electric Distribution Planning shall supply Protection Engineering with the current circuit operating map showing the location of the primary metered customer. In addition, Electric Distribution Planning shall obtain the following information from the customer:

   a. One–line diagram of the customer–owned equipment which includes relay functional assignment and customer load or transformer kVA.

   b. Coordination curves (TCC) for customer–owned protective devices including size and type of fuses and relay settings.

   c. DC schematic of control scheme equipment showing size and type of protective devices in use if relays and breakers are utilized.

2. Use the relay/fuse coordination table (Design Standard 6134) and the PTI/PSSU program "Short Circuit Analysis" to confirm that the available line–to–ground short circuit current at the end of the fuse's zone–of–protection is <u>not less than</u> the fault current value given in the table.

   When coordination between the substation relay and sectionalizing fuse does not exist, the following alternatives are suggested. If none of these alternatives are desirable, Protection Engineering should be consulted.

   a. The existing branch fuse size may be reduced provided fuse/fuse coordination is maintained.

   b. A sub–branch fuse may be installed at the point on the branch where the short circuit current falls below the amount required to insure fuse sensitivity margin for the branch fuse.

   c. The substation ground relay setting may be raised provided the required short circuit current to insure adequate relay sensitivity margin on the feeder line segments and unfused local distribution branches is maintained. If this is the desired alternative, Protection Engineering approval should be requested by submitting a completed "Relay Setting Change Notice" along with confirmation that relay sensitivity margin is maintained.

d. The minimum line–to–ground short circuit current provided in the relay/fuse coordination table may be reduced provided the branch is strictly underground with a continous neutral conductor tied solidly to the substation.

Example:

$I_{fL-G,\ REDUCED} = .83 \times (I_{fL-G})\ TABLE$

The fuse may not protect an overhead line via an up cable pole unless the up cable pole QA fuse coordinates with the CLF.

3. Use the relay/fuse coordination table to confirm that the relay's instantaneous trip (IT) setting for both phase and GND is higher than the value provided in the table for a given fuse size and type. If the IT is lower than the value provided, notify Protection Engineering that the IT value needs to be raised.

4. Use the fuse/fuse coordination tables and the RAP program "Short Circuit Analysis" to confirm that the available short circuit current at the protecting fuse is not more than the fault current value given in the appropriate table.

   When coordination between sectionalizing fuses does not exist, the following alternatives are suggested. If none of these alternatives are desirable, Design Planning should be consulted.

   a. The size of the fuse in the protected position may be raised provided the relay/fuse coordination is maintained.

   b. The size of the fuse in the protecting position may be lowered provided fuse/transformer coordination is maintained.

   c. A different type of fuse (substituting an expulsion fuse for a CLF) may be used provided the available fault current is low enough.

   d. The fuse device in the protecting position may be bridged.

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EXAMPLE:

Perform a Distribution Circuit Performance Analysis for 12kV circuit 460. The required circuit operating map is shown in attachment B, the Relay Test Record in attachment A and the RAP program output in attachment D.

STEP 1 – Fault Detection

a. Refer to the "Relay Test Record". The phase relay is type CO–8 (attachment A, reference 1) set at 600 amps (reference 2) on lever 1 (reference 3). The ground relay is type CO–8 (reference 4) set at 240 amps (reference 5) on lever 3 (reference 6).

b. The minimum permissible short circuit current in the relay's zone–of–protection is:

$$I_{f\ GND,\ min} = 3(240) = 720 \text{ amps}$$

$$I_{f\ PHASE,\ min} = 2(600) = 1200 \text{ amps}$$

c. Refer to the RAP program "Short Circuit Analysis" (attachment D). The available short circuit current at the end of the relay's zone–of–protection on the feeder line segments and the unfused local distribution branches does not fall below 720A L–NEUT or 1200A 3–PHASE.

EXAMPLE: At switch 152–T3–460 (attachment B1, reference 166) the available short circuit currents at the end of the zone–of–protection are $I_{f\ GND}$ = 2,019A and $I_{f\ PHASE}$ = 2,911A (attachment D, reference 1).

d. Circuit 460 is protected with 150A fuses and, therefore, fuse protection of these branches requires a minimum L–NEUT short circuit current of 450 amps. Scan the RAP program "Short Circuit Analysis" to see if any branches have a L–NEUT fault current below 450A. The 60A fuse (attachment D, reference 2) has only 311A at the end of its zone–of–protection (reference 401). The 60A fuse requires at least 180A fault current for adequate protection therefore, no changes are required.

STEP 2 – Individual Distribution Circuit Reliability

a. Refer to the circuit operating map (attachment B). The only potential for an additional switch is at the intersection north of the substation (reference 1). Because there is negligible load between the intersection and existing switches surrounding the intersection (references 2 & 13), additional switches are not required.

b. The up cable pole (reference 1581) requires an expulsion fuse which coordinates with the CLF at Del Sol Blvd.

c. Branch 20 (reference 20) is 3,300 feet long according to the RAP program and therefore requires a fuse.

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STEP 3 – Protective Device Coordination

a. The circuit does not have any primary metered customers which would require coordination review by Protection Engineering.

b. According to the relay/fuse coordination table, a 150A type QA fuse must have at least 1200 amps of available short circuit current at the end of the fuse's zone–of–protection to coordinate with a CO–8 relay set on lever 3 at 240A (attachment C, reference 1). The 150A QA fuse at section 20 (attachment B1, reference 20) has only 862 amps available. Because the full load current on the fuse is only 72 amps, the fuse size may be reduced to 125A which will coordinate with the relay.

   The 150A type EJO–1 fuses at section 167 (attachment B2, reference 167) require 1,740 amps of short circuit current (attachment C, reference 2) and only 1,543 amps are available. To increase the available short circuit current within the fuse's zone–of–protection, a fuse cabinet may be installed where the terminator is presently located (attachment B2, reference 1800). The new fuse cabinet must sense 1,543 amps while the existing fuses will see at least 1,800 amps. This is sufficient for relay coordination.

c. Refer to the "Relay Test Record" (attachment A). The IT setting for the phase relay (reference 7) is 2,640 amps and is equal to the ground relay setting (reference 8). In order to coordinate with the 150A type QA fuse, the relay IT setting must be at least 2,500A (reference 3). Because the IT setting is 2,640A, no change is required.

d. Use the fuse/fuse coordination tables (Design Standards 6131, 6132, 6133) to be sure that the fuses coordinate.

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RELAY TEST RECORD
FORM 111-244

STATION	SAN YSIDRO	12.5 KV CIRCUIT	460	SH. NO. 1

PROT	TYPE	AMP/VOLT	ITA	MODEL/STYLE	SERIAL NO.	LOCATION	I.B. NO.
OC A (1)	CO-8	4-12	10-40				
B	"	"	"				
C	"	"	"				
G__ D (4)	"	2-6	"				
RECLSR	KSV						
DIR. PWR							

CT. TYPE	1200/5	AMM. SCALE	

CT. RATIO	600/5	AMM. MULT (7)	PT. RATIO

(2) PHASE OVERCURRENT RELAY

	TV 600	1200	1800	2640		–	2640	2400	–	RECLSR SETTING 0-20 SEC 120 SEC CYCLE
IF										
%I	100	200	300	440	(3)	TLS	ITA.			REMARKS
IRLY	TAP 5	10	15	22		1	22	20	–	
	TIME / PU	1.9	.80	.45			SPU	NPU	SCALE	TEST BY / DATE

P.U. AND TIME TESTS													
	A												
	B												
	C												
	A												
	B												
	C												
	A												
	B												
	C												
	A												
	B												
	C												
	A												
	B												8-16-73
	C												KARL A. BERLIN

(5) RESIDUAL GROUND RELAY (8)

	TV 240	480	1200	2640		–	2640	2400	–	REMARKS
IF										
%I	100	200	500	1100	(6)	TLS	ITA.			
IRLY	TAP 2	4	12	22		3	22	20	–	
	TIME / PU	6.0	1.2	.68			SPU	NPU	SCALE	TEST BY / DATE

TESTS													
	G												
	G												
	G												
	G												
	G												

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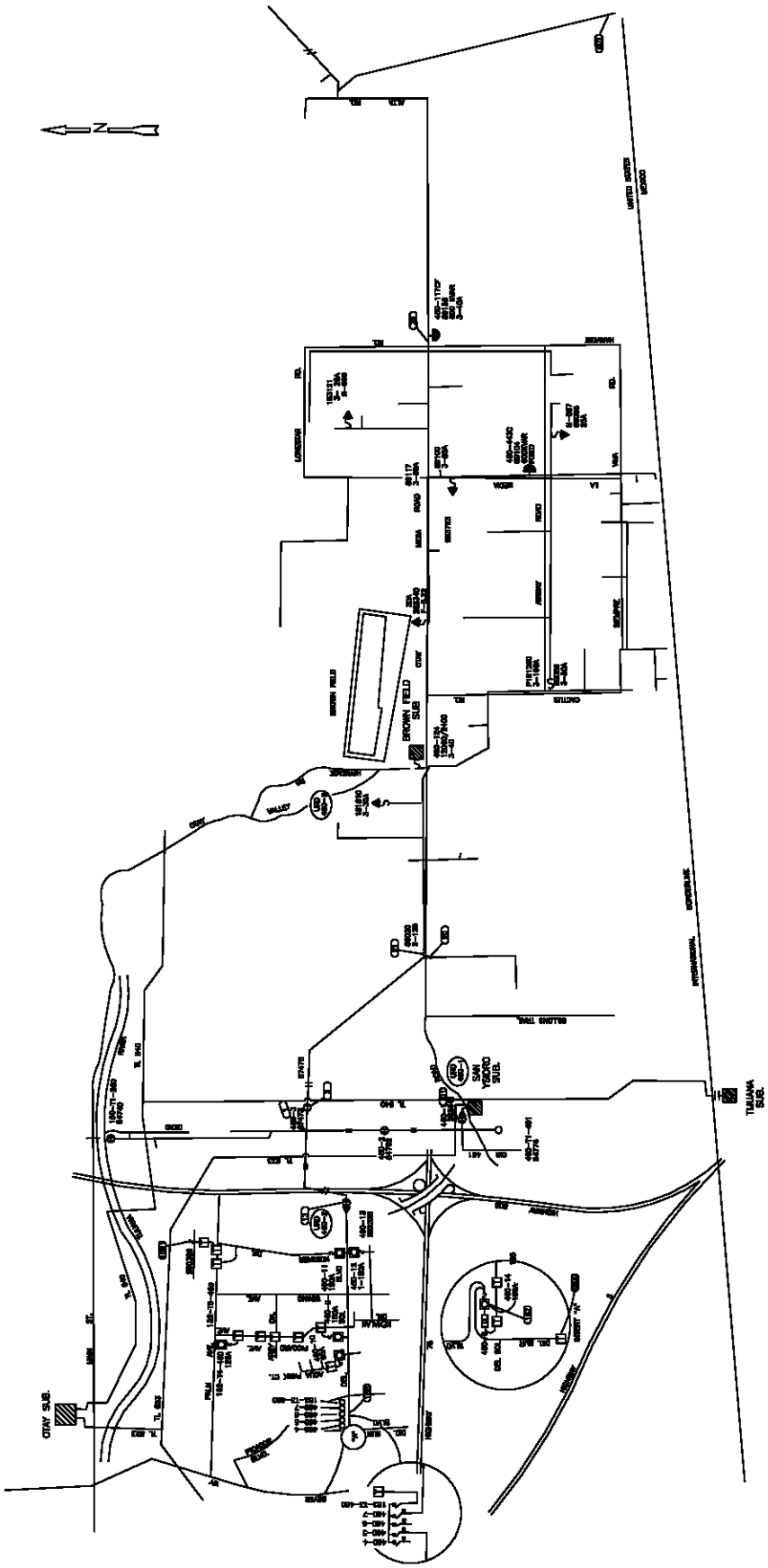
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SAN DIEGO GAS & ELECTRIC COMPANY
SAN DIEGO, CALIFORNIA

12KV CIR.460 SAN YSIDRO SUB

DRAWN BY: K. CLINE
TRACED BY:
CHECKED BY: R.M. COGILL
APPROVED BY:
SCALE:
DATE: 6-1-74
REV. NO. 0
REV. DATE 2-17-83
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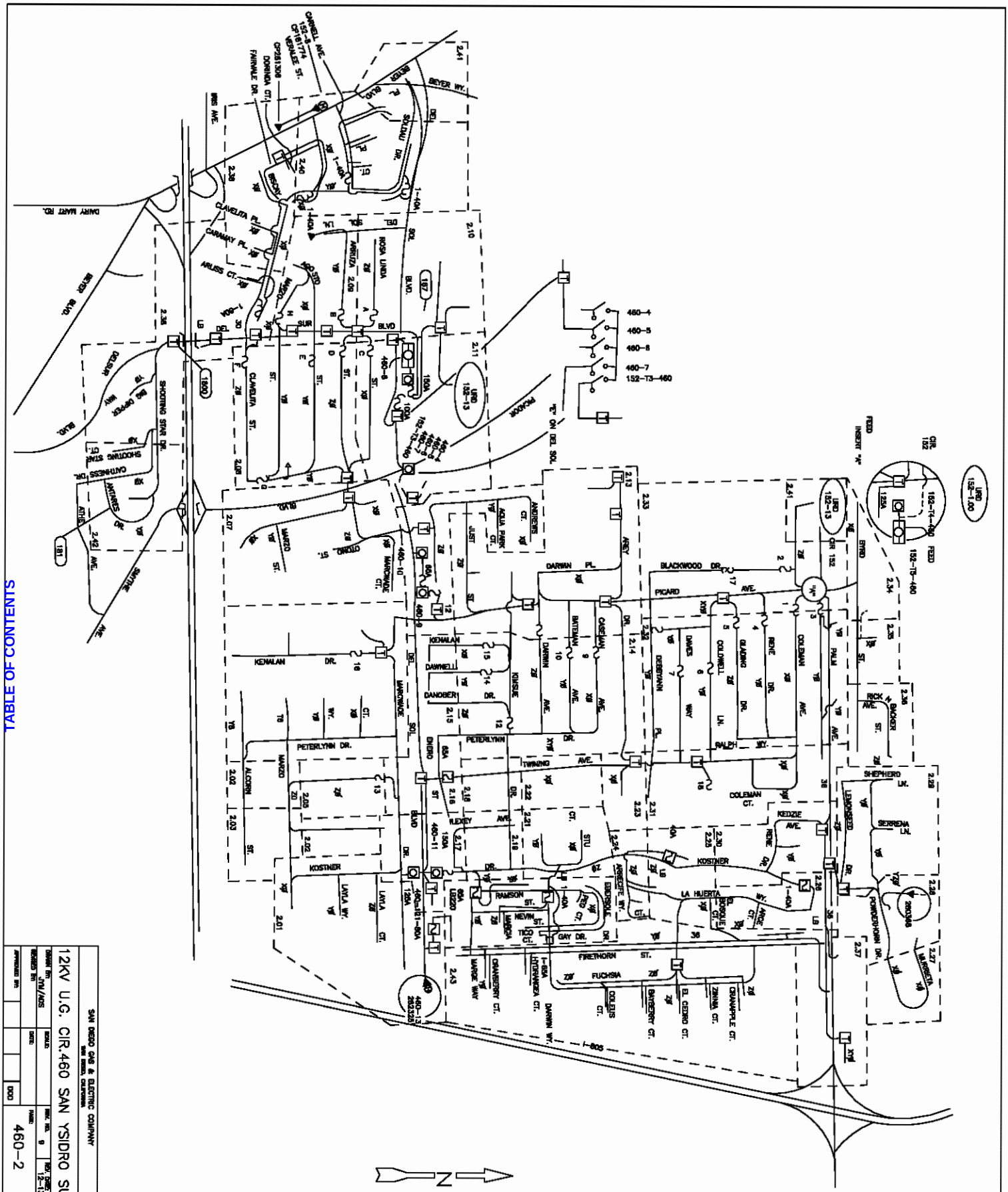


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MINIMUM R.M.S. AMPERES FOR SAFE COORDINATION (e)

RELAY TYPE	GROUND RELAY SET AT 150 AMP													GROUND RELAY SET AT 240 AMP										GROUND RELAY SET AT 300 AMP					
	QA					EJO–1				KB			S&C	RTE	QA				EJO–1			KB	S&C	RTE	QA		EJO–1		KB	S&C	RTE
CO–8 Lever	75	100	125	150	200 (a)	80	100	150	200 (a)	80	150	200	150		100	125 (1)	150	200 (a)	100 (2)	150	200 (a)	150	200	150	150	200 (a)	150	200 (a)	150	200	150
1	*	1950	3300	4800	8400	*	1050	2700	3900	750	2850	8400	3900		*	2100	3900	7800	*	2160	3600	2040	6900	3300	2700	7200	1950	2940	1425	6000	2250
2	*	*	1350	2730	5400	*	900	2040	2910	*	2070	4800	2460		*	*	1500	4800	*	1830	2700	1410	3900	1800	*	3900	1680	2490	*	2400	*
3	*	*	*	1800	3900	*	*	1830	2670	*	1770	3450	2100		*	*	1200	3600	*	1740	2460	1290	2340	1350	*	2220	1530	2340	*	1920	*
4	*	*	*	1500	3300	*	*	1770	2490	*	1350	2820	1650		*	*	*	2430	*	1650	2340	*	1980	*	*	1800	*	2190	*	1740	*
5	*	*	*	1260	2700	*	*	1710	2400	*	1320	2460	1290		*	*	*	2100	*	1530	2250	*	1800	*	*	1650	*	2100	*	1650	*
IAC53 Lever																															
1	1350	2640	3750	5250	9000	675	1200	3000	4200	900	3300	8700	4200		1350	3300	4800	8400	900	2670	3750	2700	7800	3750	3900	8100	2190	3000	2040	6900	3450
2	*	*	2250	3750	6750	*	960	2250	3300	*	2160	6300	3600		*	*	2700	6000	*	1980	2850	1560	5400	2340	*	5100	1800	2700	1290	3600	1650
3	*	*	1110	2700	5400	*	900	2040	2850	*	1800	5100	2400		*	*	1500	5100	*	1830	2670	1380	3600	1800	*	2640	1650	2430	*	2220	*
4	*	*	900	2100	4500	*	840	1890	2700	*	1560	4200	2100		*	*	1275	4300	*	1800	2460	1320	2550	1650	*	2040	1560	2400	*	1920	*
5	*	*	*	1500	3900	*	*	1800	2550	*	1350	3450	1800		*	*	*	3000	*	1710	2400	1260	2190	1290	*	1800	*	2280	*	1740	*
CO (1) Lever																															
1	*	*	2100	3750	6600	*	*	2250	3300	*	2160	5850	3300		*	*	2460	6000	*	1980	2940	1560	5100	2250	1170	5400	1800	2670	1290	4200	1650
2	*	*	840	2100	4500	*	*	1950	2700	*	1620	4500	2100		*	*	1200	4200	*	1770	2550	1290	2850	1500	*	2490	1560	2370	*	1920	8
3	*	*	*	1350	3750	*	*	1800	2550	*	1350	3300	1650		*	*	*	2700	*	1650	2400	1260	2040	1275	*	1890	*	2250	*	1680	*
4	*	*	*	1230	3000	*	*	1740	2400	*	1290	2700	1500		*	*	*	2100	*	1560	2280	*	1920	*	*	1740	*	2100	*	1650	*
5	*	*	*	1200	2550	*	*	1650	2370	*	1260	2340	1350		*	*	*	1890	*	1500	2160	*	1680	*	*	*	*	2100	*	1630	*
IT>	1250	1500	2000	2500	3750	650	800	1500	1800	800	1700		2000		1500	2000	2500 (3)	3750	800	1500	1800	1700		2000	2500	3750	1500	1800	1700		2000

NOTES:

(a) Permission from Protection Engineering must be acquired prior to use.

b. For settings below those given in the table and for the relay types not mentioned in the table contact Protection Engineering.

c. If the relay time lever setting is between the two given values (i.e., TL = 1–1/2) pick the lower time lever (i.e., TL = 1)

d. If the ground relay setting (TV) is between the two given values (i.e., TV = 200A) choose the lower setting (i.e., TV = 180A)

(e) Coordination values are 3 times higher than curve crossing to provide adequate sensitivity margin. Values may be reduced (.83 multiple) for an underground fuse provided a continuous neutral solidly tied to the substation exists to the fuse location.

REFERENCE:

1. Design Standard 6144, Distribution Circuit Analysis

* Will coordinate for all I_f (T< 1Ø SEC)

SHORT CIRCUIT ANALYSIS

460 SAN YSIDRO NONCVR VOLTAGE. 3-3-83 BASE CASE

FEEDER NUMBER: 460 INPUT DATA SET = ED.ED505RAPM(N)R CASE = 105

-SECTION- FROM	TO	KV	PHASE	CONDUCTOR OR TFMR	SECT K-FT	ACCUM K-FT	METER AMPS	-SHORT CIRCUIT CURRENT- 3-PHASE AMPS	L-L AMPS	L-NEUT AMPS	--PER UNIT IMPEDANCE ON 1MVA BASE-- -POSITIVE SEQUENCE- R	X	-ZERO SEQUENCE- R	X
165	166	12.47	3-Y	#2 CU PECN	0.13	15.91	41	3008	2605	2077	0.00508	0.01453	0.01145	0.0342
166	167	12.47	3-Y	#2 CU PECN	0.70	16.61	41	2911	2521	2019 (1)	0.00595	0.01475	0.01307	0.0345
167	17	12.47	3-Y	#2 CU PECN	0.34	16.95	35	2863	2480	1991	0.00638	0.01486	0.01386	0.0341
17	170	12.47	3-Y	#2 CU PECN	0.90	17.85	21	2739	2372	1916	0.00750	0.01515	0.01595	0.0351
170	18	12.47	3-Y	1C#2 ALPECN	0.23	18.08	5	2683	2324	1880	0.00801	0.01528	0.01688	0.0352
18	1800	12.47	3-Y	2/0 AL PECN	0.28	18.36	5	2646	2292	1868	0.00829	0.01541	0.01688	0.0352
1800	180	12.47	L-N	1C#2 ALPECN	0.44	18.80	13	.	.	1800 (6)	0.00926	0.01567	0.01867	0.0363
180	181	12.47	L-N	1C#2 ALPECN	1.87	20.67	6	.	.	1543 (5)	0.01338	0.01676	0.02625	0.0392
170	171	12.47	3-Y	2/0 AL PECN	1.10	18.95	11	2594	2247	1869	0.00862	0.01563	0.01595	0.0352
171	172	12.47	3-Y	2/0 AL PECN	0.70	19.65	8	2507	2171	1840	0.00933	0.01594	0.01595	0.0352
172	173	12.47	3-Y	2/0 AL PECN	0.20	19.85	5	2483	2151	1831	0.00953	0.01602	0.01595	0.0352
173	174	12.47	3-Y	2/0 AL PECN	0.55	20.40	2	2419	2095	1809	0.01009	0.01627	0.01595	0.0352
174	175	12.47	3-Y	2/0 AL PECN	1.20	21.60	1	2287	1981	1761	0.01131	0.01679	0.01595	0.0352

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SHORT CIRCUIT ANALYSIS

460 SAN YSIDRO NONCVR VOLTAGE. 3-3-83 BASE CASE

FEEDER NUMBER: 460 INPUT DATA SET = ED.ED505RAPM(N)R CASE = 105

-SECTION- FROM	TO	KV	PHASE	CONDUCTOR OR TFMR	SECT K-FT	ACCUM K-FT	METER AMPS	--SHORT CIRCUIT CURRENT--- 3-PHASE AMPS	L-L AMPS	L-NEUT AMPS	--PER UNIT IMPEDANCE ON 1MVA BASE-- -POSITIVE SEQUENCE- R	X	-ZERO SEQUENCE- R	X
33	34	12.47	3-Y	#4 CU	1.70	35.30	24	733	635	545	0.05119	0.03697	0.06386	0.1190
34	340	12.47	3-Y	#6 CU	3.45	38.75	8	636	551	481	0.06046	0.04050	0.07436	0.1320
34	35	12.47	3-Y	#4 CU	1.77	37.07	25	695	602	517	0.05418	0.03871	0.06747	0.1256
35	36	12.47	3-Y	#4 CU	1.80	38.87	25	660	572	491	0.05723	0.04048	0.07114	0.1320
36	360	12.47	3-Y	#6 CU	3.95	42.82	2	571	494	431 (2)	0.06785	0.04452	0.08316	0.1470
360	361	12.47	3-Y	#2 AL	3.20	46.02	1	529	458	400	0.07334	0.04765	0.08976	0.1592
36	362	12.47	3-Y	#6 CU	2.60	41.47	2	598	518	450	0.06422	0.04314	0.07905	0.1422
362	363	12.47	3-Y	#6 CU	2.40	43.87	1	551	477	418	0.07067	0.04559	0.08635	0.1513
36	37	12.47	3-Y	#4 CU	0.25	39.12	26	656	568	488	0.05765	0.04073	0.07165	0.1333
37	38	12.47	3-Y	#4 CU	4.95	44.07	3	577	500	429	0.06602	0.04560	0.08174	0.1518
38	39	12.47	3-Y	#4 CU	3.72	47.79	2	529	458	393	0.07232	0.04926	0.08933	0.1658
39	390	12.47	3-Y	#4 CU	0.80	48.59	0	520	450	387	0.07367	0.05005	0.09096	0.1688
39	40	12.47	L-N	#4 CU	1.00	48.79	4	.	.	385	0.07401	0.05028	0.09137	0.1695
40	41	12.47	L-N	#4 CU	3.83	52.62	1	.	.	355	0.08048	0.05416	0.09917	0.1699
40	401	12.47	L-N	#4 CU	10.86	59.65	3	.	.	311 (3)	0.09238	0.06131	0.11351	0.2093
1	12	12.47	3-Y	336 AL	3.60	11.70	209	3409	2952	2381	0.00391	0.01301	0.00839	0.0300
12	13	12.47	3-Y	336 AL	1.00	12.70	209	3205	2775	2181	0.00424	0.01381	0.00908	0.0330
13	14	12.47	3-Y	750ALXLPEPJ	0.20	12.90	209	3192	2765	2175	0.00429	0.01385	0.00922	0.0330
14	140	12.47	3-Y	750ALXLPEPJ	0.58	13.48	207	3158	2735	2157	0.00441	0.01398	0.00960	0.0330
140	1400	12.47	3-Y	2/0 CU PECN	0.58	14.06	19	3072	2661	2108	0.00514	0.01417	0.01095	0.0340

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SCOPE

This standard defines the steps Electric Distribution personnel should follow when performing a benefit/cost reliability analysis.

PURPOSE

The reliability analysis discussed herein is used to compare the cost effectiveness of construction alternatives and to prioritize projects. Special consideration may be given may be given to certain loads.

CRITERIA

SAIDI, SAIFI, and MAIFI are the primary indicies used for reliability analysis and are defined below. Based on a circuit's historical and predicted performance in SAIDI, SAIFI, and MAIFI, it shall be prioritized among other circuits for analysis and potential improvements. Reliability analysis shall study the historical and predicted performances of the distribution circuits and identify potential improvements.

$$\text{SAIDI} = \frac{\text{Number of Customer} - \text{Minutes Interrupted from Sustained Interruptions}}{\text{Number of Customers Served}}$$

$$\text{SAIFI} = \frac{\text{Number of Customers Interrupted from Sustained Interruptions}}{\text{Number of Customers Served}}$$

$$\text{MAIFI} = \frac{\text{Number of Customers Interrupted from Momentary Interruptions}}{\text{Number of Customers Served}}$$

BACKGROUND

SDG&E has been measuring distribution circuit performance using SAIDI, SAIFI, and MAIFI for many years. Measuring system performance in this way has resulted in standards designed to reduce the number of customers affected by sustained or momentary outages (e.g. fuse and service restorer application) and reduce the length of sustained outages (e.g. line and tie switch and fault indicator application). The following equip-ment application standards were developed to be used conjunctively with this section by Distribution System Standards personnel:

6111 – Feeder Circuit Sectionalizing and Protection (Switch Application Criteria)
6112 & 6114 – Service Restorer Application Criteria
6113 – Automatic Self-Resetting Fault Indicator
6121 – Fuse Application Criteria
6144 – Distribution Circuit Protection Analysis
6232 – Circuit Tie Capacity Planning

APPLICATION

Historical and Predicted Analysis:

The two stages of the reliability analysis are Historical and Predicted; they provide a means to validate each other. The historical data is obtained through outage history databases and district records. Predicted quantities and impacts are derived from circuit modeling as described later in this section. The following components should be compared for differences between the two stages:

* Outage Duration
* Outage Frequency
* Momentary Frequency
* Failure Modes
* Customer Complaints
* Magnitude of Affected Load
  - MW
  - Number of Customers
* Key Loads
* Load Transfer Capability During Outages

Project Development and Evaluation Methodology:

A benefit/cost analysis is used to compare the cost effectiveness of construction alternatives and prioritize projects. Reliability benefit is derived from the predicted annual improvement in the key indices, SAIDI, SAIFI, and MAIFI. The project cost is annualized by multiplying the capital cost by the current LACC (Levelized Annual Carrying Charges) factor. The benefit/cost (B/C) ratios are defined as:

SAIDI B/C= (Predicted System SAIDI Improvement)*(Total System Customers)/ [(Capital Project Cost)*LACC]

SAIFI B/C = (Predicted System SAIFI Improvement)*(Total System Customers)/ [(Capital Project Cost)*LACC]

MAIFI B/C = (Predicted System MAIFI Improvement)*(Total System Customers)/ [(Capital Project Cost)*LACC]

The predicted reliability improvements are calculated using the present average failure rates, restoration times, and customers affected. Failure rates vary by exposure, type, condition, and age of equipment and are typically projected from historical trends. Average rates are usually applied to classes of construction (e.g. underground and overhead) and may be more discretely defined with sufficient data. Restoration times are also estimated by past performance and should be modified for special conditions, such as rural circuits requiring lengthy travel time or remote SCADA operation. A sample predicted improvement calculation is shown below.

Assuming Current Failure Rate for Unjacketed Cable System = 0.4 failures/mile/year

Assuming Current Failure Rate for Jacketed Cable System = 0.01 failures/mile/year

Cable Considered for Replacement = 2000 feet

Assuming Estimated CAIDI (Customer Average Interruption Duration Index) Based on Configuration and Past Performance = 90 minutes

Customers Exposed to Sustained Outage = 3000

Total System Customers = 1,200,000

LACC = 0.1515

Prior to Improvements:

Predicted System SAIDI Impact = (0.4)*(2000/5280)*(90)*(3000)/ (1200000) = 0.0341

After replacing the 2000 feet of unjacketed cable with jacketed cable:

Predicted System SAIDI Impact = (0.01)*(2000/5280)*(90)*(3000)/ (1200000) = 0.000852

System SAIDI Improvement = 0.0340

Assuming $30/foot for cable replacement, the benefit/cost is:

SAIDI B/C = (0.0340)*(1200000)/[(2000)*(30)*(0.1515)] = 4.488

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This predicted SAIDI and benefit/cost calculation is performed more comprehensively and efficiently using circuit modeling computer software. The currently used application is described below.

Circuit Modeling Software:

The Reliability Analysis Program performs predicted SAIDI and SAIFI calculations, based on a circuit model. In addition, it contains a Tie Capacity Worksheet for verifying the adequacy of potential circuit ties in the model, as explained in Design Manual section 6232. The current Software, Software Users Manual, and Additional Tips document are available to SDG&E employees through Electric Reliability Improvement. The Main Menu, shown in Figure 1, provides push button access to the data entry and analysis worksheets. The circuit is modeled and predicted reliability calculated through entry of conductor data in the Conductor Lengths worksheet (see Figure 2) and sectionalizing equipment in the Circuit Analysis worksheet (see Figure 3). The Equipment Listing worksheet (see Figure 5) lists standard equipment with estimated installation costs. The Switching/Repair Times worksheet (see Figure 4) contains average restoration times based on historical results. These can be adjusted for higher accuracy when modeling circuits in remote locations that require longer personnel travel time. For alternative cases, construction costs can be entered in the Circuit Analysis worksheet for benefit/cost calculation. SAIDI B/C is labeled VR and the SAIFI B/C is labeled VB (see Figure 3).

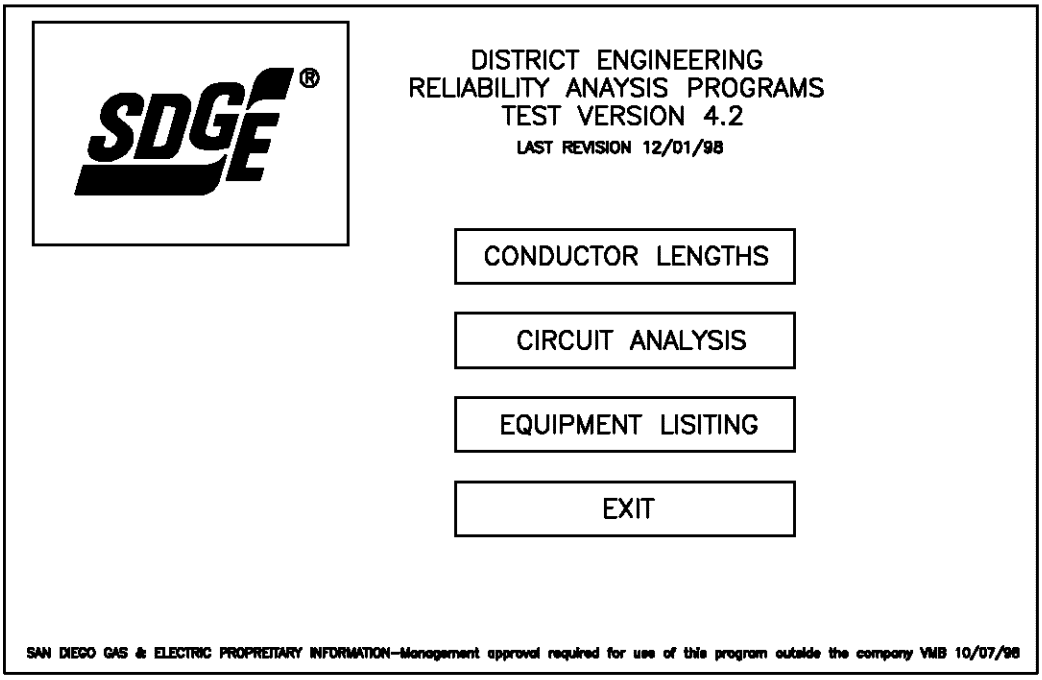


Figure 1 – Main Menu

OC	CIRCUIT	310	BY:	Alan Dulgeroff								DATE:	******
FEEDER 1			FEEDER 2				FEEDER 3				FEEDER 4		
CB			FROM	−35			FROM	−21			FROM	SA	
−34			TO	−18			TO	−16			TO	−50	
PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ
0	0	5,083	0	0	1,685	832	0	10	625	2.377	0	0	494	0
0	2,640	3,500	0	0	0	0	1,970	0	0	0	2,510	0	0	0
0	0	0	0	0	0	0	0	0	1,095	0	0	10	490	0
0	0	0	0	0	0	0	0	0	0	0	0	100	1,015	884
0	0	0	0	0	0	0	0	0	0	0	0	685	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	680	280
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

BRANCH B1			BRANCH B3				BRANCH B5				BRANCH B7			
−33			FROM	−20			FROM	−28			FROM	−49		
−14			TO	END			TO	FUSE			TO	T4−794		
PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ
287	0	1,843	0	25	990	112	0	0	535	0	0	25	3,772	617
0	2,640	3,500	0	450	1,673	45	1,300	0	0	0	0	0	0	0
0	0	0	0	120	1,359	45	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

BRANCH B2			BRANCH B4				BRANCH B6				BRANCH B8			
−32			FROM				FROM	−22			FROM	−48		
T3−312			TO				TO	FUSE			TO	FUSE		
PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ	OVERHEAD	PECN	XLPE	XLPEPJ
0	0	1,250	0	0	0	0	0	0	536	0	0	0	330	280
0	0	0	0	0	0	0	1,430	0	0	0	880	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

F1	B1	B2	F2	B3	B4	F3	B5	B6	F4	B7	B6	TOTALS
0	0	0	0	0	0	1,970	1,300	1,430	2,510	0	880	8,090
0	287	0	0	595	0	10	0	0	795	25	0	1,712
2,640	0	0	1,685	4,022	0	1,720	535	536	2,619	3,772	330	17,859
8,583	1,843	1,250	832	202	0	2,377	0	0	1,164	617	280	17,148

Print

Analysis

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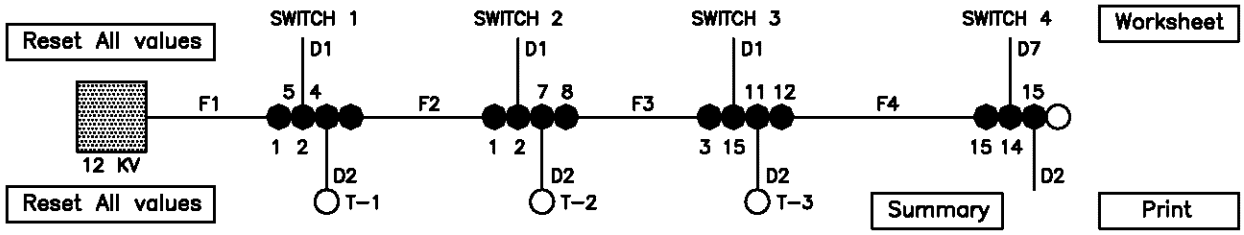
Reset All values

Transfer Values To Model

Figure 2 − Conductor Lengths

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DISTRICT	OC	CIRCUIT	310	IER	$ 5.33	SYSTEM CUSTOMER	1,189,081	BY:	Alan Dulgeroff & Stacy Williams
RECOMMENDED IMPROVEMENT									
						SAIDI TARGET:	0.100	DATE:	09/01/1999



NO SWITCH = N. GANG/HOOKSTICK = G, FUSE = F, RESTORER = R, VISTA INTERRUPTER = Y

SWITCH 1	BASE	CASE 1
$1-1	$	$
$1-2	$	$
$1-3	$	$
$1-4	$	$
T-1	$	$

SWITCH 2	BASE	CASE 1
$2-5	G	G
$2-6	G	G
$2-7	G	G
$2-8	G	G
T-2	N	N

SWITCH 3	BASE	CASE 1
$3-9	G	G
$3-10	G	G
$3-11	G	G
$3-12	R	R
T-3	N	N

SWITCH 4	BASE	G
$4-13	G	G
$4-14	G	G
$4-15	G	G
T-4	G	G

Restoration

FEEDER/BRANCH CONDUCTOR LENGTHS IN FEET — Reset Conductor Lengths

CONDUCTOR	F1	B1	B2	F2	B3	B4	F3	B5	B6	F4	B7	B6	TOTALS
OVERHEAD	0	0	0	0	0	0	1,970	1,300	1,430	2,510	0	880	8,090
PECN	0	287	0	0	595	0	10	0	0	795	25	0	1,712
XLPE	2,640	0	0	1,685	4,022	0	1,720	535	536	2,619	3,772	330	17,859
XLPEPJ	8,583	1,843	1,250	832	202	0	2,377	0	0	1,164	617	280	17,148

RECOMMENDED REPLACEMENT LENGTHS IN FEET — Reset Replacement Lengths

PECN	0	0	0	0	0	0	0	0	0	0	0	0	0
XLPE	0	0	0	0	0	0	0	0	0	0	0	0	0
CUSTOMERS	6	219	0	0	342	0	457	808	50	697	73	1,723	4,375
PEAK AMPS	0	0	0	0	0	0	0	0	0	0	0	0	0

TOTAL PROJECT COST	$0	PV	VR	VB	BASE CASE	CASE 1	NET GAIN	BASE CASE	CASE 1	NET GAIN
		–	–	0.000	0.300	0.304	0.003	0.00482	0.00482	0.00000

Exit

CIRCUIT 310

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Figure 3 – Circuit Analysis

Main Menu

SWITCH 1	BASE	CASE 1
$1–1	$	$
$1–2	$	$
$1–3	$	$
$1–4	$	$
T–1	$	$

SWITCH 2	BASE	CASE 1
$2–5	G	G
$2–6	G	G
$2–7	G	G
$2–8	G	G
T–2	N	N

SWITCH 3	BASE	CASE 1
$3–9	G	G
$3–10	G	G
$3–11	G	G
$3–12	R	R
T–3	N	N

SWITCH 4	BASE	G
$4–13	G	G
$4–14	G	G
$4–15	G	G
T–4	G	G

COMPONENT FAILURE	OUTAGE IMPACT BY SWITCHING/REPAIR TIMES ON LOAD POINTS											
	FEEDER 1		BRANCH 1		BRANCH 2		FEEDER 2		BRANCH 3		BRANCH 4	
	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1
F1	3.50	3.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B1	0.25	0.25	2.50	2.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B2	0.25	0.25	0.25	0.25	2.50	2.50	0.25	0.25	0.25	0.25	0.25	0.25
F2	0.25	0.25	0.25	0.25	0.25	0.25	3.50	3.50	1.00	1.00	1.00	1.00
B3	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	2.50	2.50	1.00	1.00
B4	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	2.50	2.50
F3	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
B5	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
B6	0.25	0.25	0.25	0.25	0.25	0.25	1.00	1.00	1.00	1.00	1.00	1.00
F4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00
B7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

COMPONENT FAILURE	OUTAGE IMPACT BY SWITCHING/REPAIR TIMES ON LOAD POINTS											
	FEEDER 3		BRANCH 5		BRANCH 6		FEEDER 4		BRANCH 7		BRANCH 8	
	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1	BASE	CASE 1
F1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B1	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
B2	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
F2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
F3	3.50	3.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B5	1.00	1.00	2.50	2.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B6	1.00	1.00	1.00	1.00	2.50	2.50	1.00	1.00	1.00	1.00	1.00	1.00
F4	0.00	0.00	0.00	0.00	0.00	0.00	3.50	3.50	1.00	1.00	1.00	1.00
B7	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	2.50	2.50	1.00	1.00
B8	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	2.50	2.50

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Figure 4 – Switching/Repair Times

SECTIONALIZING DEVICE	EQUIPMENT CODE	SWITCHING REPAIR/HRS	QTY REQ'D	UNIT COST	LACC	TOTAL COST	ANNUALIZED COST
OH SERVICE RESTORER	OHSR	0.00	0		0.1515	$0	$0
OH SCADA SWITCH	OHS	0.25	0		0.1515	$0	$0
OH ELECTRIC SECTIONALIZER	ESEC	0.00	0		0.1515	$0	$0
OH GANG OPERATED SWITCH	G	0.75	0		0.1515	$0	$0
OH HOOK STICK SWITCH	H	0.75	0		0.1515	$0	$0
OH FUSE/CUT OUT	F	0.00	0		0.1515	$0	$0
UG SERVICE RESTORER	UGSR	0.00	0		0.1515	$0	$0
NON SCADA SWITCH							
PME3	PME3	1.00	0		0.1515	$0	$0
PME9	PME9	1.00	0		0.1515	$0	$0
PME10	PME10	1.00	0		0.1515	$0	$0
PME11	PME11	1.00	0		0.1515	$0	$0
PADMOUNT SCADA EXISTING 3316							
PME3	SPME3	$.25	0		0.1515	$0	$0
PME9	SPME9	$.25	0		0.1515	$0	$0
PME10	SPME10	$.25	0		0.1515	$0	$0
PME11	SPME11	$.25	0		0.1515	$0	$0
PADMOUNT SCADA EXISTING 3315							
PME3	SPME3	$.25	0		0.1515	$0	$0
PME9	SPME9	$.25	0		0.1515	$0	$0
PME10	SPME10	$.25	0		0.1515	$0	$0
PME11	SPME11	$.25	0		0.1515	$0	$0
RETROFIT PADMOUNT SCADA PME TO SCADA PME							
PME3	SPME3	$.25	0		0.1515	$0	$0
PME9	SPME9	$.25	0		0.1515	$0	$0
PME10	SPME10	$.25	0		0.1515	$0	$0
PME11	SPME11	$.25	0		0.1515	$0	$0
RETROFIT PADMOUNT OIL/SF4 TO SCADA PME							
PME3	SPME3	$.25	0		0.1515	$0	$0
PME9	SPME9	$.25	0		0.1515	$0	$0
PME10	SPME10	$.25	0		0.1515	$0	$0
PME11	SPME11	$.25	0		0.1515	$0	$0
PAD MOUNT OH/OFF VISTA	YI	0.00	0		0.1515	$0	$0
UG SUBMERSIBLE SWITCH	UG	1.00	0		0.1515	$0	$0
UG FUSE INDICATORS	FC	0.00	0		0.1515	$0	$0
OH FAULT INDICATORS	OHFI		0		0.1515	$0	$0
UG FAULT INDICATORS	UGFI		0		0.1515	$0	$0
WIRE/CABLE REPLACEMENTS	REPAIR TIME IN HRS		QTY IN FT	$/FT	LACC	TOTAL COST	ANNUALIZED
OH RECONDUCTORING >=1/0	2.00		0		0.1515	$0	$0
OH RECONDUCTORING <1/0	2.00		0		0.1515	$0	$0
UG CABLE REPLACEMENT >2/0	2.00		0		0.1515	$0	$0
UG CABLE REPLACEMENT <=2/0	2.00		0		0.1515	$0	$0
MISCELLANEOUS							
			0		0.0000	$0	$0
			0		0.0000	$0	$0
			0		0.0000	$0	$0
			0		0.0000	$0	$0
				GRAND TOTAL		$0	$0

Main Menu | Print | Exit

Figure 5 – Equipment Listing

Numerous alternatives should be modeled as different cases for comparison and optimization. A suggested procedure for optimization is outlined below. Consult the Software Users Manual and Additional Tips document for further modeling instructions.

Distribution Circuit Reliability Modeling, Analysis, and Review Procedure:

Tie Capacity Analysis

* If two good ties are available based on the Design Manual section 6232 criteria, activate the ties on model.
* Consider circuit and customer locations.
* Assume a maximum of two ties to pick–up the whole circuit.

Accuracy of Base Case Comparison

* Provide GFMS predicted SAIDI, Base Case predicted SAIDI, and historical three year average SAIDI for ECO (Entire Circuit Outages) and number of ECO by type (e.g. two by cable failure and two by car–pole contact).
* If SAIDI differs significantly in the GFMS and Base Case models, verify that the total customers and unfused footages by wire type match. Only CAIDI should vary. If the CAIDI (SAIDI/SAIFI) for each differ, ensure the appro–priate switches are modeled and ties activated on base case.

Alternatives

* Prioritize cable replacement based on SAIDI improvement. High number of customers attached to cable maximizes SAIDI improvement.
* When replacing cable between switch positions, do entire run.
* While still focusing on SAIDI improvement, identify the benefits to major customers.
* Check with Planning Engineer on future circuit plans.
* Use Vista switches only if another switch alternative is not viable.
* If circuit will be split in near future, choose one of the following options using sound engineering judgment:
  1. Model circuit as is today, or
  2. Model existing circuit, accounting for transfers to or away from circuit. Other affected circuits need not be modeled.
  3. Model all changes.

Alternative Comparisons – Run separate cases for #2, #5, and #6, if applicable

1. Identify applicable fusing and electronic sectionalizers.
2. Replace all unjacketed cable that may interrupt entire circuit.
3. Prioritize cable replacement by benefit/cost ratios.
4. Identify additional switches, service restorers, SCADA switches, etc.
5. Produce two combined alternatives with the highest benefit/cost ratios.
6. Provide at least one alternative with benefit/cost ratios significantly higher than target.

Review

* For presentation to the Reliability Action Team or other approval body, use a large summary operating map or overhead transparency, with the equivalent circuit highlighted, to explain alternatives.
* Provide a package including:
  – Summary sheet for alternatives
  – Base Case analysis sheet
  – Alternative analysis sheets
  – Circuit Map(s)
* Identify the location of high failure rate cable on the circuit; do not simply use calculated footages.
* Attach large unfused branches over 500 feet to a switch.
* Consider using padmounted switches, instead of subsurface, when selecting which switches to model.

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6212	EFFECTS OF VOLTAGE UNBALANCE ON CUSTOMER EQUIPMENT:
6214	EXPANSION OF THE 4KV SYSTEM
6221	APPLICATION OF PRIMARY NEUTRAL
6230	SUBSTATION DISTRIBUTION FIELD TIE EVALUATION
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REV	CHANGE	DR	BY	DSN	APV	DATE	REV	CHANGE	DR	BY	DSN	APV	DATE
C	6222 MOVED TO FMO	JIK	FRC	FRC	KRG	09/16/2024	F	6241 MOVED TO FMO	YZZ	FRC	FRC	FRC	07/17/2026
B	EDITORIAL CHANGES	JIK	JIK	FRC	CZH	09/03/2021	E	6213 MOVED TO FMO & 6231 REMOVED	YZZ	FRC	FRC	JJP	03/17/2026
A	ORIGINAL ISSUE	-	-	JCE	MJC	11/29/2012	D	6242 MOVED TO FMO	YZZ	FRC	FRC	FRC	07/18/2025

Indicates Latest Revision | Completely Revised | New Page X | Information Removed

SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

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DM6201.1

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SCOPE

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

PURPOSE

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.

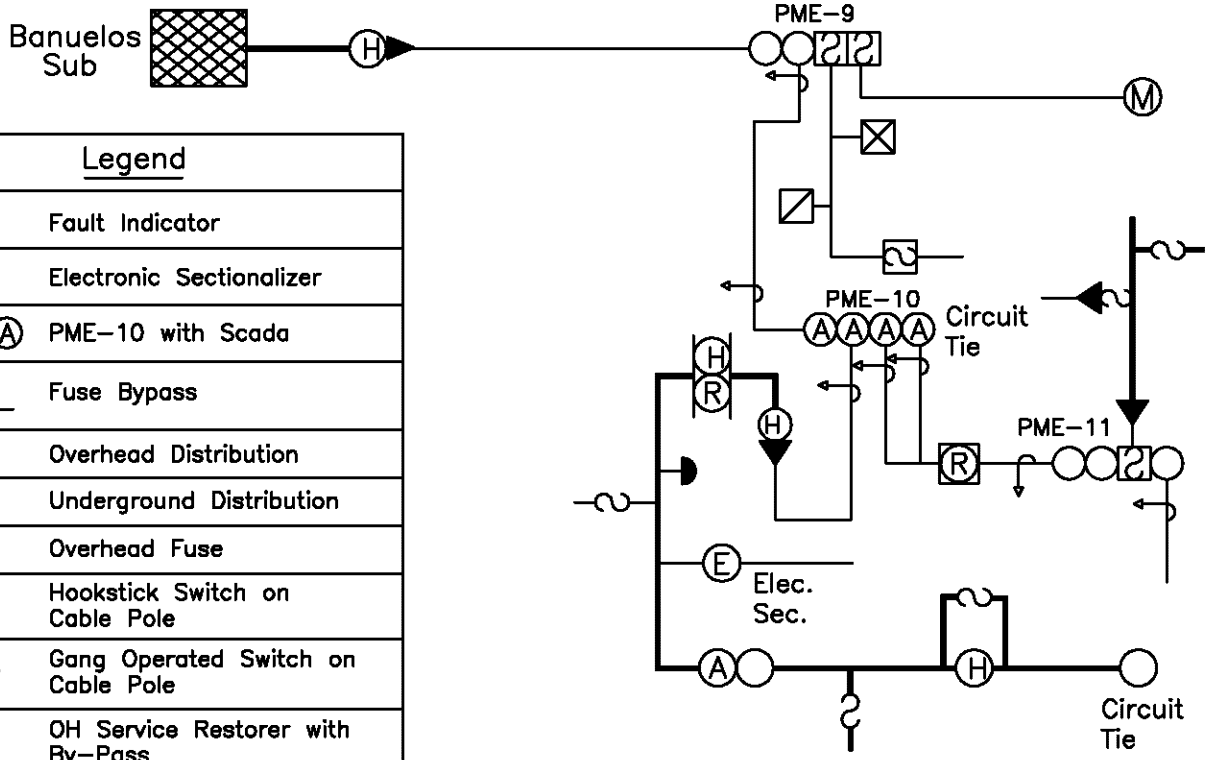
CRITERIA

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.

INTRODUCTION

Fuses, service restorers, 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.)

The purpose of the following diagram is to illustrate the types of sectionalizing devices and their application on a distribution circuit. It is not intended to depict a typical circuit.



Legend			
	Fault Indicator		
E	Electronic Sectionalizer		
A A A A	PME–10 with Scada		
H	Fuse Bypass		
	Overhead Distribution		
	Underground Distribution		
	Overhead Fuse		
H	Hookstick Switch on Cable Pole		
	Gang Operated Switch on Cable Pole		
H R	OH Service Restorer with By–Pass		
2 2 2	PME–9 Cabinet	2	Fuse Cabinet
	Gang Operated Switch		Fused Cable Pole
	Three Phase Transformer	A	Scada–Mate
M	Primary Metering Station	R	Padmount Service Restorer
	Capacitor	2 2	PME–11

	Indicates Latest Revision		Completely Revised		New Page

REVISION	SDG&E DISTRIBUTION DESIGN MANUAL	
DATE 1–1–2000 APPD MJC / VCL	SECTIONALIZING DEVICES ON DISTRIBUTION CIRCUITS	6205.1

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 highter 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 calander 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 equivlent in operability to pad mounted equipment.

SCADA equipment is by far the easiest and quickest to operate, as the Switching Center has direct, continous 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 turndown 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 Troubleshooter (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:

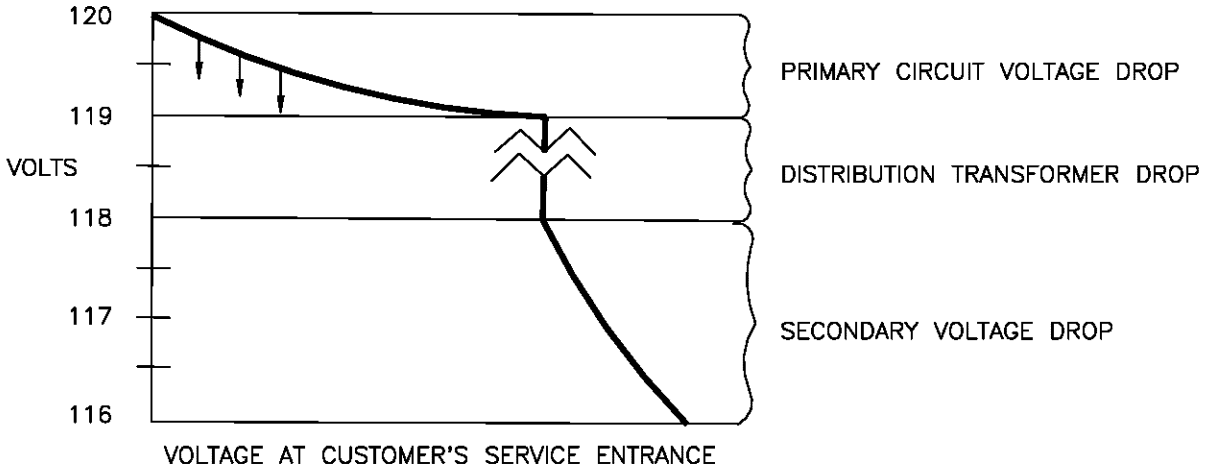
UG device providing the ability to quickly isolate UG feeder segments or equipment. Operable by a single ETS, the cam-link is a molded connector assembly including a removable, current carrying part that can be replaced with a non-current carrying counterpart. Can be operated only after both sides are tested denergized. 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.

I. LEGACY SCADA SITES:

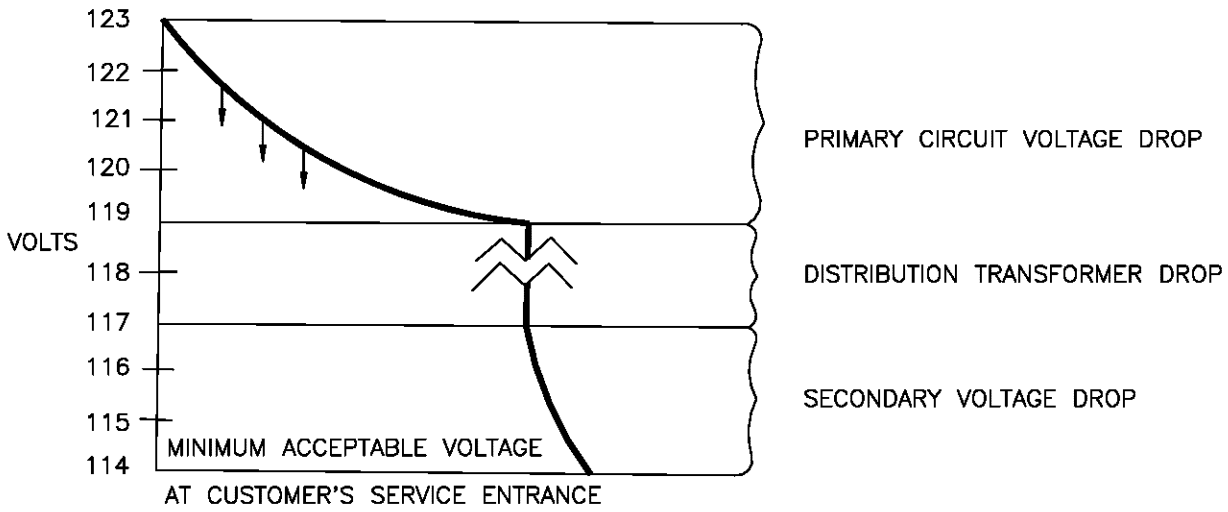
Existing "Legacy" SCADA systems-installed on selected oil and SF6 subsurface and padmount switches between 1989 and 1996, to provide basic SCADA functionality (open/close status & control, plus fault indication). These sites do not have the ability to autosectionalize, nor is it feasible to add that 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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SCOPE THIS STANDARD IS TO BE USED BY ENGINEERING AND OPERATING PERSONNEL CONCERNED WITH THE ALLOWABLE VOLTAGE BANDWIDTH.



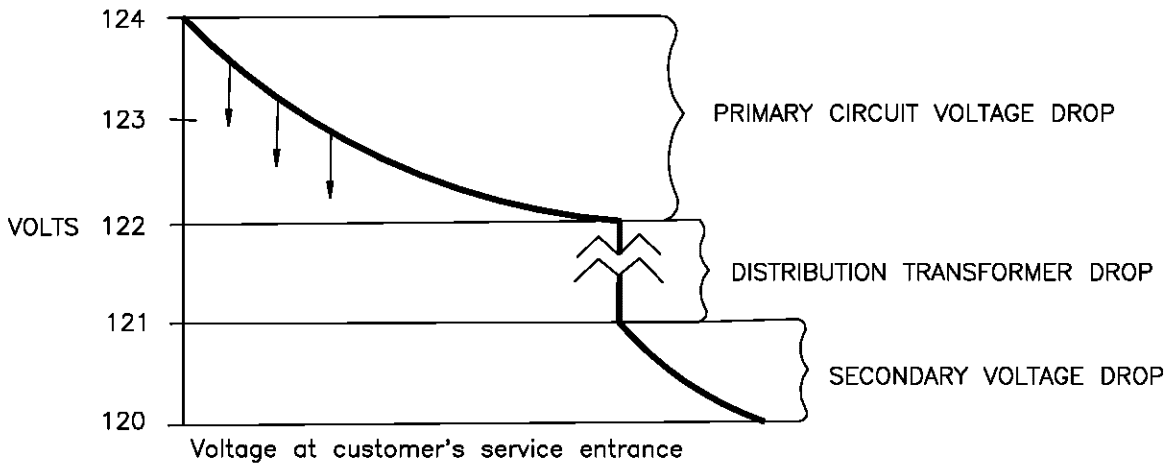
CVR VOLTAGE PROFILE – LIGHT LOAD
(CONSERVATION VOLTAGE REGULATION)



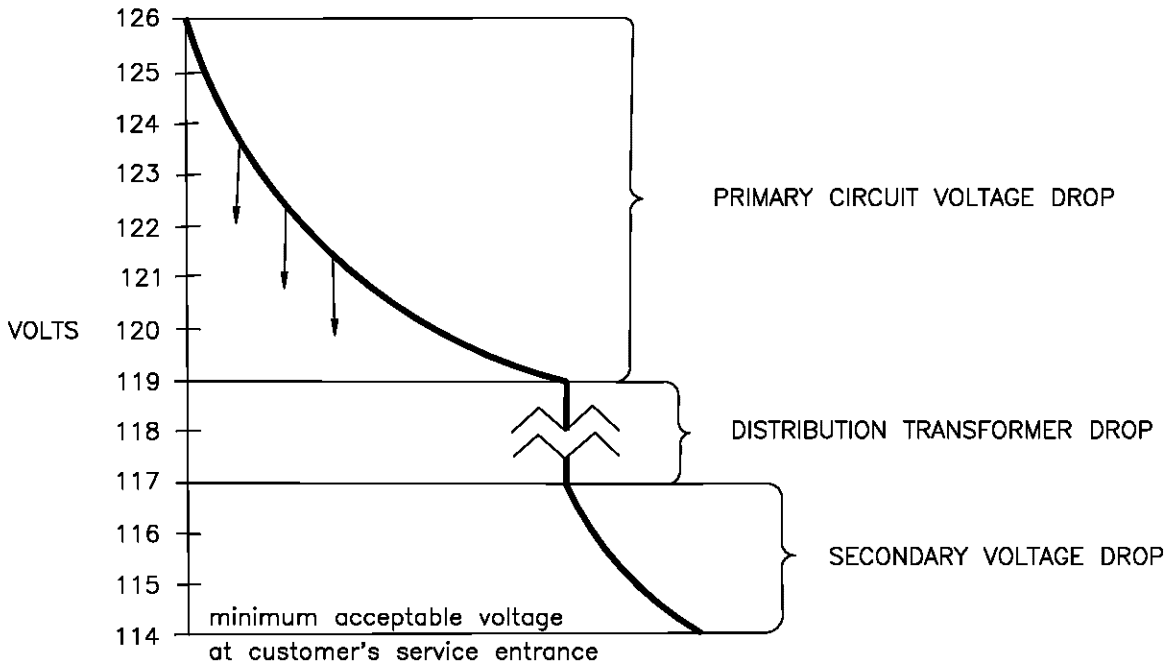
CVR VOLTAGE PROFILE – PEAK LOAD

	Indicates Latest Revision		Completely Revised		New Page
REVISION DATE 1-1-96 APPD CVN	SDG&E DISTRIBUTION DESIGN MANUAL DISTRIBUTION CIRCUIT VOLTAGE PROFILE				6211.1

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NON – CVR VOLTAGE PROFILE – LIGHT LOAD



NON – CVR VOLTAGE PROFILE – PEAK LOAD

The voltage profile computer program is a tool that the Distribution Workflow & Planning can use to determine distribution circuit conditions for future load levels. Output from this program include circuit voltage, current, impedence, losses, conductor sizes, distances and connected loads along the circuit. Base cases are constructed by using transformer sizes and conductor footage that is taken from circuit wall maps and other Company documents. For information on constructing base cases and running studies, see "Procedure for Conducting Voltage Profile Studies" triad file END 300.

Updated profile studies should be run annually for distribution circuits showing growth. It is best to start with load level projects for two or three years in the future. Analysis of the output data and application of the appropriate criteria will indicate problem areas of low voltage and/or conductor overloads. The output of this program is also used for tie capacity calculations (Design Standard 6232).

SCOPE

This design standard provides discussion of the effects of voltage unbalance on three-phase induction motors.

PURPOSE

This standard was created to inform Distribution Standards & Cost Management personnel of the effects of supplying three-phase induction motors with an unbalanced set of voltages.

DEFINITIONS

Voltage Unbalance - the maximum voltage deviation from the average s voltage as a percent of the average voltage.

$$\% \text{ Voltage unbalance} = 100 \times \frac{\text{max. voltage deviation from average}}{\text{average voltage}}$$

Motor Derating - the term applied to a reduction in a motor's rated output.

CRITERIA

1. Distribution Standards & Cost Management approval is required whenever an open-wye transformer station is intended to be installed more than five miles beyond the substation. They will determine if the open-wye station may be installed without causing a voltage unbalance problem.

2. Distribution Standards & Cost Management should improve the voltage balance on a secondary system whenever they determine that a voltage unbalance may cause equipment damage.

DISCUSSION:

Unbalanced voltage may effect a three-phase induction motor in the following way:

1. Increased Heating - An industry "rule of thumb" states that the increase in motor heating due to voltage unbalance is approximately equal to two times the voltage unbalance squared. If the voltage unbalance is 4.3% then the increased heating is approximately:

   $$2 \times (4.3 \times 4.3) = 37\%$$

   To prevent motor damage due to voltage unbalance, NEMA Standard MG1-14.34 or ANSI Standard C84.1-1982 suggest that a three-phase induction motor be derated according to figure 1 (page 6212.2).

2. Winding Currents - Unbalanced voltage will result in unbalanced moter winding currents of a larger magnitude. For example, a 4.3% voltage unbalance on a 10hp three-phase motor may result in line currents of 132%, 92%, and 85% of the rated current under balanced conditions depending on the individual charateristics of the motor.

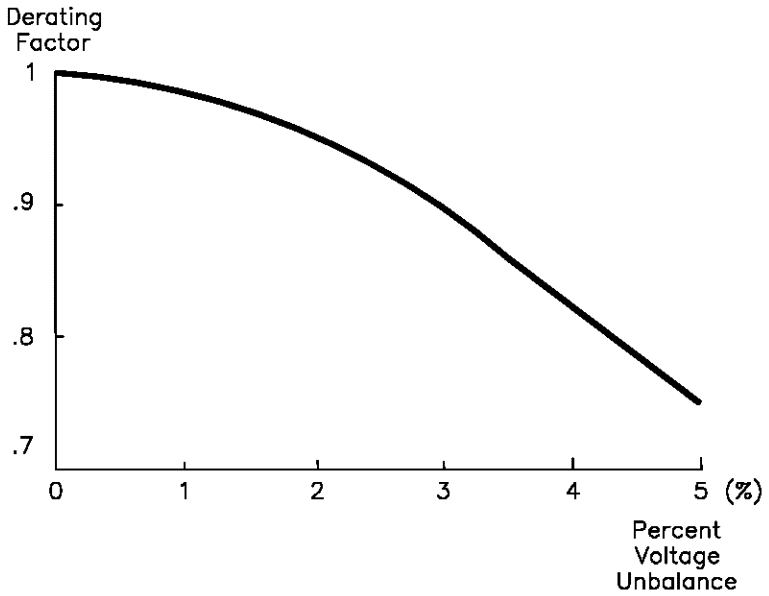
3. Efficiency - Figure 2 (page 6212.3) illustrates the impact of voltage unbalance on the efficiency of a typical 10hp induction motor. As shown, an induction motor operating with an average voltage of 230 volts and 4.3% voltage unbalance will have an efficiency of approximately 84.6%.

4. Sump pumps - three-phase submersible sump pumps of any size should not be fed from open-delta stations. (Refer to page 5413.4 note 6.d.)

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4. Decreased Speed
The decrease in shaft speed is dependent on the degree of voltage unbalance and the resulting average voltage. If the voltage unbalance is excessive, the motor will stall.

EXAMPLE:
Determine the voltage unbalance for the following set of secondary voltage readings:
Va–b = 220V
Vb–c = 230V
Va–c = 240V
average voltage = (220 + 230 = 240)/3 = 230V
voltage unbalance = (230 – 220)/230 = .043 or 4.3%

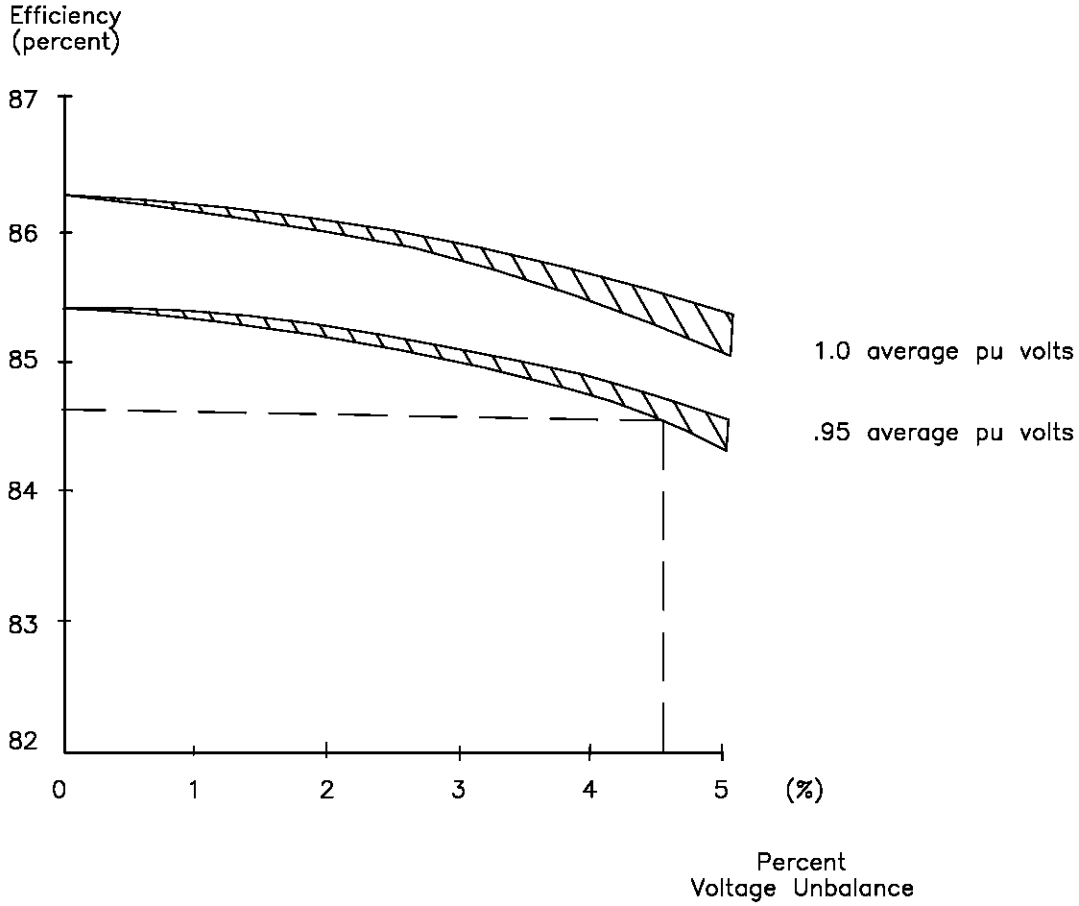


INDUCTION MOTOR
DERATING FACTOR
–VS–
VOLTAGE UNBALANCE

Figure 1

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INDUCTION MOTOR
VOLTAGE UNBALANCE
–VS–
MOTOR EFFICIENCY

Figure 2

SCOPE

This design standard outlines criteria for the expansion of 4kV systems.

Purpose

PRIMARY LINE EXTENSION - 4kV System

The general policy for expansion of the electric distribution system is to contain the 4kV areas and to cutover small selected areas from 4kV (or 2.4kV) to 12kV operation so as not to require expansion of the existing 4kV system. This will allow continued use of the existing equipment and at the same time use the more economical 12kV system for as much of the new load as possible.

All new distribution lines are to be built to 12kV standards to avoid major improvements or additions in the future when cutover to 12kV takes place.

The circuit selection for new loads will be based on the size of the load and its proximity to existing circuits. Electric Load Studies are required for any load addition to the 2.4kV or 4kV system. Other new loads within mixed voltage areas will be served by new lines built to 12kV standards. Although 12kV cutovers within these areas are not anticipated, they will be made if the economics can be proven or if required to serve a large new load at 12kV.

There are several small substations serving isolated 2.4 or 4kV systems. Some of these systems must be left in place because they serve underground cables or 4kV primary metered customers. In general, it is preferred not to extend any of these local 2.4 or 4kV systems; however, from the practical standpoint, short extensions may be necessary.

The following considerations should be reviewed by Electric Distribution Planning prior to recommending that an area be cutover from 4kV to 12kV:

1. Cost associated with complying to grade of construction (G.O. 95 Rule 42, Table 3, class of poles (G.O. 95, Rule 49.1B) and clearance for 12kV (G.O. 95, Rule 38, Table 2).
2. Number of customers on each transformer station
3. High voltage signs
4. Reconductoring
5. Lightning arrestors on 100 kVA transformers
6. Replacement of #6 WP and #6 Bare Strand on main lines
7. Retagging of the stations on the cutover as a supplement to the main job
8. Notes on the sketch such as: "Foreman note: Check phase balance before and after cutover. Rebalance circuits if warranted." and "Customer outages are to be kept to a minimum. If an outage of more than 5 minutes is necessary, contact the appropriate Region Planning Department."
9. Temporary shooflies are to be discussed with Region Design Review foreman before issuing the Cutover.
10. Primary metering stations on 4kV either overhead or underground require a memorandum to the Region Planning Department stating that the circuit is being cutover to 12kV.

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11. Replacement of all Weatherproof copper wire. See DM 5124.1.4.

12. Review with either the primary or if applicable alternate 12kV circuit to determine if any additional reliability concerns will materialize (ex. Modifications to existing midpoint or tie switch locations).

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SCOPE

This standard establishes the criteria for application of grounded neutral systems to serve single-phase 6.9kV or 7.2kV primary systems.

APPLICATION OF GROUNDED NEUTRAL PRIMARY SYSTEMS

A. Reason for Using a Grounded Neutral System

A grounded neutral system allows the application of line-to-neutral transformers (6.9kV or 7.2kV primary voltage) on underground residential systems. This application results in significant cost savings over the use of line-to-line transformers (12kV primary voltage) due to one less cable, fewer connectors, lower-cost transformers and smaller substructures.

B. Types of Neutral Sources

1. Substation Neutral

The substation neutral is the preferred neutral source. The recommended limit on cost expenditures for extending the substation neutral is two times the cost of installing a new grounding bank.

2. Grounding Banks (see Design Standard 6222)

Grounding banks are an alternate method of supplying a grounded neutral source. A grounding bank may be installed when a grounded neutral source is required and;

a. The cost of extending the neutral from the substation or from an existing grounding bank is double the cost of a new grounding bank installation.

b. The new load will not cause an overload or imbalance to the grounding bank.

Design Standards' approval is required prior to the addition of a fourth grounding bank to a distribution circuit. When there are three existing grounding banks, new load must be served from one of the existing grounding banks or substation neutral.

C. When Should Grounded Neutrals Be Used?

1. A job involving single-phase loads shall be served using 6.9kV transformers when any of the following is true:

a. The estimated cost of using 6.9kV transformers including neutral bring-up costs and/or a grounding bank is less than or equal to the cost of using 12kV transformers.

b. There is potential for future single–phase load additions to this circuit within a half–mile radius of the project location, and the estimated cost of providing a grounded neutral system is less than three times the cost savings obtainable by installing a 6.9kV system instead of a 12kV system.

Note: The allowable cost of the neutral bring–up will be put on the fuse request by District Engineering. If the cost estimated by the designer exceeds this cost, he or she should return to District Engineering for further approval.

2. In addition to jobs issued specifically to install a neutral conductor on the primary overhead system, either neutral conductors shall be included or poles shall be framed for neutral conductors in the following jobs:

a. The fourth conductor (neutral) shall be installed on all new or reconductored distribution feeders. The neutral conductor must be connected to a grounded neutral. If the neutral conductor cannot be connected to the substation ground without major expense, the use of an existing or new grounding bank neutral may be considered (see Design Standard 6222 on grounding bank information).

NOTE: Contact Electric Distribution Planning Engineer when conditions indicate framing for the neutral conductor may be preferred on reconductored or new feeders. Framing should be compatible with overall system integrity, a viable construction option, and economically advisable. Some concepts for consideration are: Fault current advantages having the neutral conductor, tie compatibility between circuits, ability to transfer load between circuits (temporary or permanent).

b. On local distribution branch work, poles shall be framed for the fourth conductor. This will minimize the cost of installing the neutral conductor at a later time.

c. Work to bring–up a phase conductor to serve a new grounding bank shall include the extension of the neutral conductor from the grounding bank to the point where the new phase conductor originates.

d. All new or reconductored three–phase local distribution branch work shall include the neutral conductor when an existing neutral is in the area.

D. Application

1. A neutral being used to supply transformers on a circuit may not originate from a different substation than the one supplying the circuit.

2. The neutral must be continuous, therefore, no fusing is permitted within a primary neutral circuit.

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D. Application (con't)

3. Neutrals shall be solidly tied together at all switches regardless whether they are normally open or closed. This includes tie switches to circuits emanating from different substations. This also includes a neutral that comes from a grounding bank.

4. The neutral in a 4–wire overhead system shall be connected to the neutral of an underground system that is tapped to the overhead. This applies even if only three–phase transformers are connected to the underground.

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1.0 PURPOSE

This document provides a standard for evaluating and coordinating the review of distribution field ties to improve substation reliability during a substation upgrade scope development. The intent is to increase the number of circuits that can be restored via ties to surrounding substations in the event of a substation outage. With the ability to off load circuits to adjacent substations, this would also reduce customers impacted by planned outages for maintenance work. This standard establishes the framework to evaluate the benefits of installing new distribution field ties and upgrading existing distribution field ties as part of substation upgrade projects. It covers priority factors that should be taken into consideration and goes through the process of looking at various distribution field tie opportunities associated with a specific substation. It also provides guidance for developing and executing the project.

2.0 REFERENCES

- OUA for number of substation outages:
  https://oua.sdge.com/analytics/saw.dll?dashboard&PortalPath=%2Fshared%2FSDGE%20Analytics%2F_portal%2FOutages
- Grid Ops for system operating diagram (SOD):
  https://gridops.sdge.com/gc/DOCS/sods.asp
- Business Warehouse for customer type by substation:
  https://biprod.sempra.com:8443/BOE/BI
- SED SharePoint for substation distance from Kearny:
  https://sempra.sharepoint.com/teams/sed/SitePages/Home.aspx

3.0 ACRONYMS/DEFINITIONS

- Kearny – Substation & transmission operations and maintenance department
- EDO – Electric Distribution Operations
- EDP – Electric Distribution Planning
- ERO – Electric Regional Operations
- ESH – Electric System Hardening
- HFTD – High Fire Threat District
- IFC – Issued for construction
- OUA – Oracle Utility Analytics
- RTR – RAT Team Rating (Reliability Assessment Team Team Rating)
- SAIDI – System Average Interruption Duration Index
- SCADA – Supervisory Control and Data Acquisition

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- SDR – Substation Design Request
- SED – Substation Engineering and Design
- SOD – System Operating Diagram
- SPACE – System Protection and Controls Engineering
- TED – Transmission Engineering and Design
- TRC – Technical Review Committee
- TST – Technical Support Team, distribution engineering support at EDO

4.0 GENERAL

This standard provides general guidance for evaluating field ties as part of substation upgrade projects. In addition to the technical merits of a project, there may be factors to consider outside the scope of this standard. Other factors may include available budget, upcoming projects in the area, or various other factors that may affect distribution field tie scope of work.

5.0 INITIATION, TRIGGERS, AND CONSIDERATIONS

5.1. Initiation

5.1.1. Upon scoping a substation distribution project, prior to the TRC presentation, the substation engineer must consider if this project will require a reconfiguration of distribution circuits. If a reconfiguration is necessary, then the substation engineer will notify the planning engineer of the respective operating district, so a distribution field tie evaluation, as it relates to a substation level outage, can be conducted.

5.2. Trigger - Substation Upgrade

5.2.1. All substation work that will alter the configuration or create new distribution getaways into the substation should be considered for field tie improvements. Examples of getaway work: Substation Rebuild, Switchgear Replacement, 12kV Rack rebuild/extension, 12kV circuit reconfiguration.

5.3. Considerations

5.3.1. 12kV Bus Tie at the Substation

5.3.1.1. A bus tie circuit breaker separates two sections of the substation bus. In the event of a 12kV bus outage, a 12kV bus tie isolates the fault and allows the other section of the bus to be restored. This can have significant effects on minimizing SAIDI impacts.

5.3.2. 12kV Bus Customer Count

5.3.2.1. The higher the customer count on a 12kV bus section, the higher the SAIDI impact will be in the event of an outage on that bus.

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5.3.3. Customer Restoration

5.3.3.1. The number of customers that can be restored via field ties in the event the entire substation is out of service.

5.3.3.2. Documentation can be obtained by emailing a TST member at EDO for a contingency plan for that substation.

5.3.4. Customer Classification

5.3.4.1. Customers are classified in Business Warehouse as either Residential or Commercial. These customers are classified a step further as "Major," Life," Essential," "Urgent" or "Sensitive."

5.3.5. Substation Accessibility

5.3.5.1. The distance in minutes from Kearny to the Substation.

5.3.5.2. The address for Kearny is 5844 Overland Ave.

6.0 PROJECT DEVELOPMENT

6.1. Once a substation has been chosen, the process for identifying and selecting opportunities to update tie capacity begins. Several considerations are outlined in the sections below.

6.2. The distribution planning engineer will inquire about other projects in the area that could help or hinder the opportunity. SDG&E has many different projects and programs that could be performing work in the same area. A list of business units that should be contacted to inquire about potential projects or programs includes, but is not limited to, ERO, ESH, EDP, TED, SED, SPACE, Major Projects, and New Business. This can be done by contacting the P6 Scheduler for the respective groups. The distribution planning engineer will evaluate opportunities for project benefits and alternatives with regards to scope combination with other concurrent/proposed projects.

6.3. The distribution planning engineer will identify all configurations where a circuit of the subject substation ties with a circuit of an adjacent substation.

6.3.1. Identify any section(s) of those two circuits that produce ampacity restrictions when the adjacent circuit would need to restore the subject circuit in the case of a substation outage.

6.3.1.1. Identify how many additional customers can be picked up by increasing ampacity ratings via reconductor. This could extend to include customers of another subject circuit that could be picked up through an existing tie.

6.4. The distribution planning engineer will look for areas where the tie between the subject circuit and an adjacent circuit does not currently exist.

6.4.1. This analysis should start by looking at circuits in close geographic proximity, location, access, and permitting to limit the scope of work needed but could expand as needed.

6.4.2. Once the proposed tie is deemed feasible, it should follow the same process as outlined in 6.3.1.

6.5. The distribution planning engineer will request the district engineer to see if the existing ties should be upgraded to the latest SCADA using an RTR calculation and historical SAIDI values for those particular circuits.

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7.0 PROJECT EXECUTION

7.1. Once a substation upgrade project is identified, the substation engineer contacts the TRC and requests a time slot for presentation of the project.

7.2. The substation engineer and the distribution planning engineer prepare a presentation. The substation engineer will present on the substation upgrades. The distribution planning engineer will present the field tie scope, including the following topics:

7.2.1. Overall Project Scope

7.2.1.1. Project description

7.2.1.2. Purpose and concerns that initiated the project scoping process

7.2.1.3. The objective of the project and timeframe

7.2.2. Primary Project Proposal

7.2.2.1. Project Scope, budget, schedule, and pros/cons

7.2.3. Alternative Project Proposal(s) if any

7.2.3.1. Project Scope, budget, schedule, and pros/cons

7.2.4. Appendix stating the evaluation processes used and any documentation supporting the proposals.

7.3. Budget Creation

7.3.1. After approval from the TRC, if the project budget is authorized, the substation engineer shall request a budget number for this project. After it is authorized, a work order for the distribution scope of work that includes the field tie improvements shall be created by the distribution planning engineer utilizing the substation budget.

7.3.1.1. The distribution planning engineer should verify if the costs from the initial distribution estimate are still applicable or if they should be adjusted. If an adjustment is needed, the distribution planning engineer shall notify the substation engineer.

7.4. Design

7.4.1. The substation engineer will work with the distribution planning engineer to determine the approved project's planned in service date. After project approval, the distribution planning engineer submits a new design service request, referencing the approved budget provided by the substation engineer, in the EDP SharePoint site for project execution. If the project is in the HFTD, the distribution planning engineer should notify the ESH Project Engineering Team Lead for informational purposes.

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8.0 INITIAL DOCUMENT AUTHORS AND REVIEWERS

DEPARTMENT	NAME
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REVIEWED BY: Manager – Electric System Hardening	Paul Greco
REVIEWED BY: Manager – Electric Distribution Planning	Matt Belden
REVIEWED BY: Operations and Engineering Manager – Electric Regional Operations	Shanna Dee
ISSUED BY: Team Lead – Equipment Engineering	Fidel Castro

9.0 REVISION APPROVALS

DEPARTMENT	NAME	APPROVED
REVIEWED BY: Manager – Substation Engineering & Design	Sneha Parmar	09/03/2021

* **Any future revisions will only require Substation Engineering approval.**

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SCOPE

This standard provides a guideline for electric distribution personnel to follow in preparing circuit improvement projects within the High Fire Threat District.

PURPOSE

- Reduce likelihood of the power distribution system being the cause of a fire event
- Reduce impact of power-line related fire
- Increase the ability of the distribution system to withstand wild land fire conditions
- Increase reliability in the backcountry areas

DEFINITIONS

Clear Recovery Zone (CRZ) – Area adjacent to unimproved roadways extending from the edge of driven way.

Edge of Driven Way (EDW) – On an unimproved roadway (without a concrete curb and gutter), the EDW is defined as follows:

1. If there is an asphalt berm, EDW is the edge of the berm farthest from the roadway.
2. If there is no berm but there is a white fog line, EDW is the edge of the fog line farthest from the roadway.
3. If there is no berm or fog line, EDW is the edge of the pavement.

High Fire Threat District Tier-2 – The broad area that has been determined by SDG&E to be at heightened risk for wild fire based on vegetation, land topology, and prevailing wind conditions. Boundaries are not generally changed.

High Fire Threat District Tier-3 – An area which designates a higher level of risk compared to areas within the High Fire Threat District Tier-2. Boundaries of the High Fire Threat District Tier-3 may change annually.

Risk Matrix – Ranking spreadsheet evaluating multiple risk factors. This matrix is used to determine the order for project analysis.

Wireless Fault Indicator (WFI) – An overhead fault indicating device that senses and reports faults (along with load) with the ability to adjust the fault detection trigger point based on steady state load.

REFERENCES

1. Design Manual 5129 Distribution Phase Spacing
2. Design Manual 6111 Feeder Circuit Sectionalizing and Protection
3. Design Manual 6112 Overhead Service Restorer Application Criteria
4. Design Manual 6113 Automatic Self-Resetting Fault Indicator

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5. Design Manual 6121 Fuse Application Criteria
6. Electric Standard Practice 322 SEL Overhead Fault Indicators
7. Overhead Construction Standard 788 Hot Line Clamps and Stirrups
8. Overhead Construction Standard 1276 Overhead Autoranging Fault Indicator
9. Overhead Construction Standard 1600 Wildlife Protection

APPLICATION

The methods and procedures described herein apply to any distribution work (Reliability or Capacity) within the High Fire Threat District Tier-2 that involves pole work or reconductor work.

PROCEDURE

1. Project Development

   a. Initial analysis will be conducted on a circuit-section basis. Sections have been identified and reviewed by the key groups (District & Planning Engineers, Operations, Vegetation Management, Fire Coordinator, Environmental, and Cultural). The order of analysis will be determined by the risk matrix. Large sections may be divided into smaller sections to facilitate project development at the discretion of the District Engineer. Developed projects will then be prioritized for construction by the risk matrix. Prior to detailed engineering analysis, the study sections are to be fielded to confirm mapping accuracy and to evaluate exposure.

   b. The recommended process is for the District Engineer to review the study segment for broad modification with input from the Planning Engineer. Detailed equipment review and change determination should be accomplished by a Project Designer, Electric Construction Supervisor, and Line Checker, or Electric Troubleshooter (ETS) under the direction of the District Engineer and O&E Manager.

      i. District Engineer – broad engineering approach, considering:

         – Transfer load out of, and sectionalize along, High Fire Threat District Tier-2 border and the border of portions of High Fire Threat District Tier-3 that are not adjacent to High Fire Threat District Tier-2.

         – Cutover lower distribution voltages to 12kV, improving protection.

         – Evaluate adding additional phase conductor(s) to improve load balance.

         – Review capacitor installation (pad-mount, SCADA control, relocate).

         – Evaluate appropriate circuit hardening method.

         – Single stations off long branches:

            1) Notify Land Department of stations with no connected load.

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2) Evaluate loaded stations for possible off-grid solution.

- Determine locations for fault indicators.
- Determine switch locations and type.
- Electronic sectionalizers – remove/replace with more advanced devices.
- Review coordination for all protective devices.

ii. Line Checker/ETS/Designer/Construction Supervisor – detailed review, considering:

- Replace transformers without pressure relief valves. Transformers installed prior to 1973 did not have pressure relief values.
- Replace porcelain insulators where wood construction is to remain.
- Replace porcelain lightning arresters.
- Replace hot line clamps connected directly to the line (i.e. without stirrups.)
- Reconductor span(s) with more than three splices on the same phase in the span.
- Spans with dissimilar conductors (size or material type).
- Cutouts with solid blades – replace with "cutout style" 900 Amp disconnect switch (Stock number S707006) and WFI.
- Initiate Engineering review for all spans where phase spacing/wire slop is a concern.

c. Project naming convention. For tracking data analysis purposes, name the projects as follows:

circuit number:year_CFSP_description

Description key:
WS = wood to steel conversion
TW = steel poles with tree wire
SC = steel poles with spacer cable
UG = traditional UG construction
CIC = UG using cable in conduit construction
Plus any other brief descriptive narrative needed

Example: C440:2011_CFSP_WS, CIC, SCADA SWITCH (2)

2. General Considerations

a. The goal is to maximize the effectiveness of the circuit hardening budget. For all construction options consider:

- Rerouting the circuit and/or transferring loads to adjacent circuits.

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- Possible off-grid approach for small loads at the end of long branches.
- Cutover to eliminate 2400V and 4160V distribution.
- Elimination of boosters.
- Future expansion plans (review with the area Planning Engineer).
- Work with appropriate contact in District to review any specific concerns they might have (e.g. lines that are difficult to inspect and patrol, location of frequent outages, etc.).
- Elimination of light duty wire (lower tensile strength, i.e., #6 copper, #4 copper), especially in high wind areas.

b. Interdepartmental Coordination:

Contact must be made early in the process with Environmental Services, Land Services, Vegetation Management, and the Fire Coordinator for input and coordination. It has proven to be very beneficial to have all the interested groups (Engineering, Land, Design, Survey and Environmental) perform the initial detailed field survey together. If LIDAR data is to be incorporated submit the request early in the process as lead times for LIDAR date can be several months.

c. Fielding:

- Vehicles must stay on access roads. Vehicles must turn around in established or designated areas only.
- Avoid disturbing all vernal pools.
- Driving through drainage areas is okay.
- Parking or driving underneath oak trees is not allowed except in established traffic areas.
- Avoid ground disturbance in public areas.
- Contact Environmental Services for any questions regarding field work.

d. Avian Protection:

Check Overhead Construction Standard 1610 to determine if the area is in an Avian Protection Zone. Include required avian protection for proposed area of hardening in these zones.

3. Hardening Approach

The recommended construction approach, in general, is determined by the geographic/vegetation topology encountered:

Situation	Construction
High tree impact with suitable road ①	Convert to UG (paragraph 3.a.)
High tree impact with no useable roads	Hendrix Spacer cable on steel poles (paragraph 3.b.)

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Moderate tree impact with no useable roads	Tree wire on steel poles (paragraph 3.c.)
Low tree impact with suitable road	Convert to UG or steel pole bare-wire (paragraph 3.d.)
Other fire area construction	Steel pole bare-wire (paragraph 3.d.)

① San Diego County or Orange County maintained road.

a. Undergrounding

When the route for underground circuitry is established, contact Land Services to verify permitting and easement issues for the route chosen.

Note that a CRZ is required along unimproved roadways. The County of San Diego has a desired minimum CRZ of eight feet. Caltrans has a desired CRZ of 30 feet for high speed (>45 mph) roadways and 20 feet on conventional highways. For slopes greater than 1:4 (up or down) some jurisdictions do not enforce the CRZ. In these installations, facilities should be placed within the sloped area as far as possible from the EDW. When placing equipment, every attempt should be made to locate padmounted equipment and poles as far from the EDW as possible. Traffic bollards should not be placed on unimproved roadways. Visibility strips should be placed on equipment.

If the equipment is not readily visible or may be obscured by vegetation, traffic bollards may be placed near the equipment as long as they are designed to break away and have visibility strips on them. Bollards may not be placed within eight feet of the EDW.

b. Spacer Cable (1/0 aluminum, 336 aluminum, 636 aluminum)

Spacer cable has many advantages over standard open wire construction. These include greater strength, insulated cable protection, compact construction and capability for longer spans.

This option is less aesthetically pleasing due to the unusual configuration and should be avoided in residential or urban areas with significant traffic.

c. Tree Wire (1/0 ACSR, 336 ACSR, 636 ACSR)

Tree wire is a useful option in areas where there is the possibility of incidental contact (palm fronds, small tree limbs, birds etc.) and where spacer cable would be visually obtrusive. The increased strength of spacer cable (nearly twice that of tree wire), is preferred in areas where contact with heavy limbs or entire trees is possible, even if all required tree trimming is done.

d. Conductor Sizing

Conductor sizes for overhead construction will be based on required strength for the High Fire Threat District Tier-2 and High Fire Threat District Tier-3. Electrical loading is not the sole consideration.

Feeder: Utilize 336 ACSR or 636 ACSR depending on current and future loading needs, and tie capacity (check with Distribution Planning for information on future loads and tie capacity).

Branch:

i. Bare Wire: Utilize #2 5/2 Alumoweld Aluminum Conductor (AWAC) for branches equal to and below

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5000-foot elevation. Utilize #2 3/4 AWAC for branches over 5000-foot elevation. The AWAC conductor provides greater tensile strength than the ACSR due to its multiple steel stranding and Alumoweld composition.

ii. Insulated Wire (Spacer Cable, Tree Wire): Use 1/0 for all insulated-wire branches.

e. Re-Routing

Consider re-routing lines when there is an opportunity to lower fire risk or to improve reliability and maintenance access. Re-routing refers to a minor or major change in current alignments. Typical re-routes involve moving equipment closer to accessible roads and away from trees and vegetation, or out of cross-country runs.

f. Equipment Considerations

i. SCADA Operated Switching/Service Restorer (Recloser)

Verify Sensitive Ground Fault (SGF) protection is enabled on any upstream service restorer (SR). If the SR is an older model that does not allow SGF protection, remove or replace. If the SGF setting is greater than 10 amps, review the segment for load balancing, to enable SGF of 10 amps or less, once balanced.

Check for the amount of OH exposure downstream of a SCADA SR or other fault interrupting device. Install SCADA operated sectionalizing in areas where there is more than one mile of three-phase OH exposure between existing SCADA sectionalizing devices.

ii. Switches

Ensure sufficient switching per DM 6111 (no more than one mile between switching devices).

iii. Overhead Transformers

Identify all 7200V WYE transformers in the proposed area to be hardened and replace them with 12.0 kV line-to-line transformers, except where there is single-phase construction only and installing a second phase is cost prohibitive. Changing the transformers for line-to-line operation will help to balance load, allowing reduction of the SGF settings and may allow for smaller fuses. Customer voltage will be somewhat higher, but still within limits.

Transformers without pressure relief valves shall be replaced. Transformers installed prior to 1973 did not have pressure relief valves.

iv. Capacitors

Evaluate the existing capacitors with the area Planning Engineer to determine the need to retain. Overhead capacitors have been identified as the most problematic device in rural distribution.

Evaluate circuit modifications that would facilitate capacitor bank elimination or relocation. (In wood-to-steel areas, the increase in conductor size may allow removal. Confirm with Distribution Planning.)

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RURAL DISTRIBUTION CIRCUIT REBUILDING ANALYSIS

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If the area is subject to extreme winds and/or heavy vegetation, replace existing capacitors with SCADA controlled capacitors or review for possible pad-mount SCADA capacitor application. Consider relocation of overhead banks to areas of lesser risk, preferably a paved area.

v. Regulators

Review all proposed regulator installations with the area Planning Engineer. All new regulators will include SCADA.

vi. Fuses

Review fusing on the segment and upstream devices for compliance with DM 6121. The objective is fire risk reduction, and this may require that some devices will not coordinate. Consult with the Fusing Specialist.

Replace expulsion fuses with SMU-20 type fuses.

vii. Fault Indicators

Analyze circuit for fault indication – non-fused cable poles, long un-fused branches, or downstream of any un-fused branch, or areas where patrol may be difficult due to terrain, etc., or on the feeder where fault interrupting devices may be mis-coordinated. WFIs may be used in all areas, including where steady state load is five Amps or less at all times.

When considering a location for a WFI, LPCN communication coverage should be confirmed with the C&O District Engineer. If communication is not present, contact Electric Distribution Engineering for assistance. (See Electric Standard Practice 322 for installation guidelines.) All manually operated, normally closed switches should include a WFI.

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SCOPE:

This standard provides the analytical method necessary to assess whether a tie deficiency exists on a distribution circuit.

PURPOSE

Tie capacity analysis is performed to identify feeder segments that will be subjected to an extended outage if additional tie capacity is not provided.

CRITERIA

The distribution feeder system is generally planned as an open loop with sufficient spare capacity in the conductors to allow a reasonable amount of load to be transferred from one circuit to another. The capacity of each circuit tie is the additional load that could be served using the adverse forecast scaled by the appropriate tie utilization factor without exceeding the emergency load rating of the conductor or causing the resultant primary voltages to be below the tolerable level of 115 volts (on a 120V base). The tie utilization factor is the % of load which will not be exceeded for a specific majority portion of the year.

In order to calculate tie deficiency, it is assumed that in the event of a feeder outage, a maximum of three ties can be used to restore service to a faulted circuit. Total tie deficiency is estimated using the worst case outage (which may not necessarily be an outage to the entire circuit). To determine the deficiency, calculate the amount of load that can be restored coincidently by using not more than three switches, then subtract this amount from the total load subjected to the outage. Do not overlook the fact that the capability of ties to restore service is dependent not only on the capacity of the tie but also on the configuration of the circuit suffering the outage. For example, line switches are critical for effective use of the capacity of a tie switch.

A. Tie Capacity

Circuit reliability analysis described in design standard 6145 will identify tie deficiencies. Tie capacity improvement projects shall be prioritized in the same manner as other reliability projects.

B. Service Restoration Projects

Feeder segments which can be served by adjacent circuits (with adequate tie capacity) can be restored in advance of repairs. Feeder segments which cannot be served by adjacent circuits (tie deficient) will be restored as repairs progress.

Service conditions following the use of line and tie switches shall not violate the following guidelines.

1. Resultant conductor loadings shall not exceed ratings for emergency or short–time operation.

2. Resultant primary (12kV) voltages shall not be below the tolerable level of 11,500 volts (115V on 120V base).

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INTRODUCTION

Computer models of distribution circuits are often used to predict when capital improvements must be made, toavoid overload, low voltage, or reliability problems. These models make certain assumptions about load density and demand factor that, in some cases, may not accurately reflect line conditions. The ability to gather actual data from the line, on a continuous basis, can improve the timing of capital improvements. The deferral of significant capital improvements can result in substantial savings by avoiding the installation of excess capacity.

The quantities monitored can include current, voltage, real and reactive power, and power factor.

PROCEDURE

There are two alternatives for monitoring distribution lines:

A. Dedicated line monitors that provide current, voltage, real and reactive power, and power factor, continuously, through the distribution SCADA master computer. – These are described in OH standard 540.1. A construction standard for underground distribution has not been developed: contact standards for information. Data from these devices is down–loaded to DWP from the SCADA master computer, along with data from substations.

B. Installation of a modem and dial–up phone line connection to later model service restorers. – In some cases, this can be done at a much lower cost than the separate, dedicated line monitor. The dial–up phone allows retrieval of data from the control at any time, with a PC, software, and modem, including the following:

1. real time instantaneous and thermal (15 minute average) current
2. draghand current (since last reset)
3. status of AC power to the control, recloser contacts, reclosing, ground protection, alternate minimum trip, and local/supervisory switch.
4. total number of operations
5. a log of the last 50 events, including loss and restoration of AC (control) power, overcurrent trip, reset, and manual trip or close. Fault currents, or load currents are recorded with each event.

Use of the dial–up feature requires that the service restorer use the "4C" digital control. Service restorers installed since the beginning of 1994 use the 4C digital control exclusively. control exclusively. But, any recloser with a serial number of 11,199 or later, is directly compatible with the 4C control. ALL padmounted service restorers use the 4C control. On existing overhead service restorers with a serial number of 11,199 or later, the 4C control can be used to replace the older 3A analog control directly, with no work required on the poletop recloser unit. Contact Distribution Standards for cost and order–ing cost and ordering information for the 4C digital control. Contact Electric Construction & Maintenance (Kearny) to confirm the serial number of any existing service restorer, and to con–firm and to confirm the model of control installed.

When a service restorer is used in this manner, none of the other operating features are affected. With the local/supervisory switch in the local position, it is not possible to change the status of the service restorer, or change any of the control settings.

Note that the dial–up feature on service restorers does not provide voltage, real or reactive power, or power factor data. All service restorers operate solely through information gathered from internally mounted current transformers. No voltage sensing elements are present, other than those confirming the presence of secondary power in the control.

DESIGN REQUIREMENTS

Early in the design process, the planner should contact electric standards to confirm the requirements for these installations. Some aspects of the SCADA Design Checklist apply, for the dedicated line monitor. For the service restorer dial–up option, telecommunications must confirm the availability of a telco phone line for the site. Not all service restorers are located close to an existing telco line. The use of cellular phone service to retrieve data from service restorers may be an option, but as of this writing has not been attempted. not been attempted. Materials for the dial–up option must be special ordered, as none are M&S stock items.

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SDG&E ELECTRIC DISTRIBUTION DESIGN MANUAL

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SUBSTATION ENGINEERING

SCOPE

This standard establishes firm capacity and short-term overload ratings for distribution substation transformers based on temperature rise of the transformer core and coils. The Transformer Loading Guide appearing on page 3 does not consider limitations imposed by substation ancillary equipment such as tap changers, bushings, breakers, etc.

This standard is to be used as a guide for planning capacity additions to distribution substations to prevent excessive loss of life of substation transformers. However, the District Engineering staff must determine the ratings of other substation equipment which may prevent designing the substation to the values provided in the Transformer Loading Guide.

CRITERIA

A. Guideline Background and Application

1. The Transformer Loading Guide is based on ANSI guidelines for transformer operation under normal and contingency conditions. Specifically, the following criteria were used to generate the Transformer Loading Guide.
   a. Transformer maximum hot spot temperatures:
      1) 180 Degrees C for 65 Degrees C rise banks.
      2) 150 Degrees C for 55 Degrees C rise banks.
   b. Transformer maximum top oil temperature: 110 Degrees C
   c. Maximum permissible loss-of-life per transformer per contingency: 0.5% (refers to Substation Equipment Specification N0. S003-103023)
   d. Maximum seasonal loss-of-life under normal conditions: 1%
   e. Nameplate capacity assumes substation transformers have similar impedances so that the load is shared equally among the banks. When this is not the case the nameplate capacity must be reduced so that no transformer serves more load than the value permitted for a single bank substation.
2. In addition, peak load values were developed with the assumption that, after the failure of one transformer in a substation, the following system operating procedures are implemented:
   a. By the operation of automatic control equipment, sufficient load is dropped within 15 minutes to prevent excessive loss-of-life on the remaining transformer(s).
   b. Additional load is transferred to an adjacent substation within four hours to prevent excessive loss-of-life on the remaining transformer(s).
   c. Load is reduced to normal limits within 12 hours by picking up the surplus load on a portable power transformer.
3. Load levels at which load-shedding equipment is to be installed at a substation are given in the Transformer Loading Guide under the heading "Note 2". The Planning Engineer is responsible for the following action regarding the load-shedding and load transfer procedures:
   a. With the cooperation and approval of Distribution Operations one or more 12kV circuits that may be dropped by automatic relay operation are to be selected.
   b. Substation Engineering will be requested to install appropriate load-shedding equipment on the preselected 12kV circuits.
   c. Distribution Operations will be advised of the location and amount of load that will be transferred to an adjacent substation using available tie switches.

B. Distribution Substations with Gas Turbines

   a. For distribution substations with one or more gas turbines, the total substation peak load will be limited to a value such that for the loss of one power transformer:
      1) The short-time loading on the remaining transformer(s), before the gas turbine can be started, will not exceed 200 percent of the maximum nameplate rating; and

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2) The loading on the remaining transformer(s), after the gas turbine is started and loaded to its normal peak rating, will not exceed the contingency condition loading limits as specified in the Transformer Loading Guide.

b. At locations where more than one gas turbine is installed, only one will be considered available for reducing transformer loadings during a contingency condition.

C. Other Considerations

a. Values contained in the Transformer Loading Guide are based on oil and hot spot temperature rise occurring within the transformer core and coils and do not consider ancillary equipment loading limitations that may exist. Substation Engineering and Substation Construction and Maintenance should be consulted to identify these limitations. Possible loading limitations associated with circuit breaker and bus overload ratings should also be identified.

b. Any transformer on SCM transformer watchlist for planned overload shall be brought to the attention of SED and SCM engineers. Transformers of high health index numbers will have limited overload capacity, and overload calculations shall be performed.

TABLE 1

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
15/20/25(28)	1	28	30/37	-	-
	2	56	60/74	38/43	32/37
	3	84	90/111	76/81	70/75
	4	112	120/148	110/115	104/109

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.

c. The actual substation rating may be less than the value published in the Transformer Loading Guide due to limitations in other substation equipment such as tap changers, bushings, breakers, etc.

d. Values contained in the Transformer Loading Guide are based on the characteristics of a typical, relatively modern transformer and average load and temperature cycles. Occasionally it will be desirable to establish a more precise rating for a unit having specific designs and load/temperature cycle characteristics.

This can be done using a computer model based on industry adopted equations for computing temperature rise within power transformers and associated loss-of-life, (NEMA TR98). Substation Engineering is willing to perform this analysis on request, provided sufficient data on the transformer in question is available

REFERENCES

I. SDG&E, Substation Equipment Specification N0. S003-103023 138/12kV Power Transformers

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SCOPE

This standard states the complete procedure for selecting, evaluating and obtaining sites for distribution substations.

PURPOSE

The selection of an appropriate site for a new distribution substation is a complex process involving advance planning studies of system expansion alternatives, followed by detailed evaluations of specific candidate sites. The selection of an optimal site requires consideration of technical, economic, environmental and political factors. The purpose of these procedures is to assure an organized and thorough evaluation of all relevant factors, and to promote clear communication between the various groups that must participate in such an evaluation. The final result of the site evaluation study should be recommendations of preferred and alternative sites for the proposed new substation.

METHODOLOGY

I. ADVANCE PLANNING PHASE

1. Area Planning Study

District Engineering conducts an area system planning study to identify need for a new substation at least 5 years in advance of need. Preliminary estimates of the following parameters are to be determined:

a. In-Service Date
b. Substation one-line diagram and approximate land requirements
c. Load Center
d. Preferred transmission voltages

Transmission Planning, Substation Engineering, Land Services, Environmental Dept., and other appropiate groups will provide input to the area planning study. Timely support from each group involved in the study is critical to the success of the process. Input from Land Services will include a recommendation on timing of a detailed site selection study. The study report must be reviewed by all study participants and Distribution Engineering and approved by District Management.

2. Capital Project Development

If substation construction and/or substation site acquisition is to occur within the 5 year period following completion of the area study, a capital project is to be developed and submitted to the Transmission and Distribution Planning Committee for approval. Estimates of all expenditures anticipated within the 5 year period are to be shown on the Capital Project Summary Form. The capital project will be presented to the Capital Budget Committee by the sponsoring district engineering group.

For capital budgeting purposes, the project manager for site acquisition will be assigned as follows:

a. Land Services if land purchase only is approved.

b. Substation Engineering if land purchase and substation construction is approved.

II. SITE SELECTION PHASE

1. Formation of a Study Team

The number of siting issues that must be considered in the selection of a substation site warrants the formation of a study team. The size and type of substation will generally dictate the number of Company department/sections that become part of the study team. The Land Planner will serve as the study team leader, and will be reponsible for requesting Substation Engineering to open a work order for the purpose of collecting the charges of the study team. Participating departments/sections on the study team could include:

Transmission Planning
Substation Engineering & Design
District Engineering
Civil/Structural Engineering
Transmission Engineering
Land Services
Environmental Department

The Land Planner should set up a study team meeting after receiving load center and other relevant information. The purpose of the meeting should be to establish responsibilities, develop a schedule for completion of the site selection, and identify project criteria, objectives, and any assumptions and biases that need to be factored into the process. Once the study parameters are defined, Land Services will identify a study area within which the search for candidate sites will occur and identify preliminary candidate sites. The study area is arrived at through a logical process based upon recognition of topographical, political, man made, or other obvious boundaries.

The following are typical site feasibility factors that will be evaluated in the site selection study and the department or section responsibility for each:

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SITE FEASIBILITY CRITERIA	RESPONSIBILITY
Physical Substation Requirements – Site size and shape – Equipment arrangement – Construction costs	Substation Engineering
Site Access	Substation Engineering Civil Engineering Land Services
Site Development & Associated Costs – Grading – Drainage – Soil Quality – Seismic Potential – Street Improvements	Civil Engineering
Distribution System Considerations – Substation transformer and low–side bus arrangement – Distribution circuit arrangements & circuit costs – Future system requirements – distribution – Overall study economic analysis	District Engineering
Transmission System Considerations – Tie line specification (voltage, routing) – Future system requirements – transmission – Substation high–side bus arrangement	Transmission Planning

SITE FEASIBILITY CRITERIA	RESPONSIBILITY
Environmental Considerations & Associated Costs	Land Services Environmental
– Archaeology – Biology – Geology – Paleontology – Aesthetic/Visual Considerations – Noise* – CEQA Requirements*	
*Substation Engineering may also be involved from a technical standpoint.	
Land Use Issues & Associated Costs	Land Services
– Building Setbacks – Deed Restrictions – Community/Specific Plan Compliance – Tentative Map Regulations/Improvements – Performance Standards (Noise, etc.) – Landscaping Requirements – Governmental Agency Requirements – Land Use Compatibility – Political Constraints/Issues – Public participation and input	
Site and R/W Acquisition	Real Property Acquisition
– Land Cost – Condemnation Issues – Severance Costs – Ownerships	

2. Identification of Candidate Sites

Given the project study area, criterion and objectives, and assumptions and biases, the Land Planner can begin the search for candidate sites. Area topographical maps, area Land Use & Environmental maps, knowledge of the study area on the part of Company Lease Agents or Property Inspectors and knowledge gained from personal field trips should be utilized to help identify candidate sites. The sites should be mapped on a base map and ownership data complied. Field trips and follow–up meetings with study team members should occur to eliminate candidate sites that have undesirable characteristics. The decision to eliminate a candidate site should occur by concenus of the study team members. Once the study group agrees upon the final candidate sites, the Land Planner should produce a memo noting this fact. The memo should also explain the reasons why other candidate sites were eliminated.

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3. Candidate Site Analysis

Final candidate sites undergo a detailed evaluation by each respective member (section) of the study team based upon the feasibility factors. For example, the engineering groups evaluate each candidate site in terms of functional operation, site development cost, and transmission and distribution system development costs. Land Services and the Environmental Dept. evaluate the land use, environmental, political and permitting implications of each site given the precise substation development scenario, i.e. arrangement of equipment, access, site topography, viewsheds, etc. Real Property Acquisition determines specific site and R/W costs. This detailed information shall become part of the decision–making analysis employed to select the preferred and alternative substation site.

Land Services is responsible for coordinating all the non–economic site analyses. District Engineering is responsible for coordinating the overall economic analysis of the alternative sites.

The detailed site selection study may identify costs and other factors significantly different than those assumed in the area planning study. Therefore, District Engineering is also responsible for review of the area planning study assumptions and results to reaffirm the need for a new substation.

4. Selection of Preferred and Alternative Site(s)

A decision–making analysis involving study team members should be employed in most instances for selecting the preferred and alternative sites from the list of final candidate sites. A Kepner–Tregoe analysis is an example of a suitable decision–making exercise. The Land Planner will coordinate the selected decision–making exercise. All memorandum required to explain and assist study team members through the exercise will be the responsibility of the Land Planner. All economic evaluations will be reviewed by the Finance and Economic Analysis Section. Obtaining concensus on what the decision–making criteria will be and how each candidate site measures up to the decision–making criteria (usually through a "scoring" system) should be the goal of the exercise.

5. Written Report

Upon completion of the decision exercise, a final report will be prepared for appropriate company management detailing the site selection recommendations.

The Land Planner will write the site selection report. The contents of the report, at a minimum, should be:

- A Summary and Recommendation Section including the justification for recommendations.
- Project Description
- Project Objectives
- Analysis of Candidate Sites (Decision Exercise)
- Supplementary Exhibits:
  - Assessor Sheets
  - Topo Maps
  - Grading Plans
  - Load Center Maps
  - Site Location Maps
  - Economic Analysis Summary
  - Decision Analysis
  - Constraint and Opportunity Maps

6. Approvals

The study report will be considered complete and "approved" when it has received signed approvals from study team participants and district management. Final approval authority and responsibility for report content rests with district management.

7. Governmental Agency and Community Involvement

Following management approval, the site selection recommendations normally will be presented by Land Planning to the Community Planning Group and/or other organized groups that may be affected by or interested in the siting of a substation. Discussion of the preferred site and transmission corridor, if necessary, along with the Company's justification for such will be the purpose of the presentation. Input from an organized group should be carefully considered because the intent of the involvement is to get community support for the project. As well, community input may have the potential to alter a recommendation if unforeseen or unknown circumstances are made known.

At the permitting stage, additional community involvement normally occurs in complying with governmental agency regulatory requirements. Public hearings on the fulfillment of use permit, parcel map, zone change, general plan amendment, etc. requirements will be handled by the Land Planner.